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CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

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A MONTHLY JOURNAL for Engineers, Architects, Surveyors & Contractors and all interested in Cement, Concrete, Reinforced Concrete, Fire-resisting Construction and Structural Steel.

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CONCRETE
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CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 1. London, January, 1921.

EDITORIAL NOTES.

THE PROGRESS OF CONCRETE CONSTRUCTION IN 1920.

HOUSING.

There is at this stage of the Government housing programme ample evidence that the prejudice which at one time existed in the minds of the public against concrete houses is fast disappearing. While those who had had experience of concrete, never doubted its constructional value and economy as a material for building small houses, the Englishman's love of the national building material—bricks and mortar—had to be reckoned with, and old prejudices die hard. However, a combination of post-war circumstances—the shortage of bricks, the scarcity of men skilled in old methods of building and the high wages demanded by them, in conjunction with the shortage of houses—has given newer methods an opportunity to prove their value, with eminently satisfactory results. The railway congestion which followed immediately on the cessation of hostilities seriously hindered the transportation of bricks, and called attention to the fact that concrete could invariably be made from materials found on, or near to, the site, thus eliminating altogether the need for transporting the greater part of the materials.

All these factors are reflected in the returns of the Ministry of Health, which show that up to the end of 1920 contracts had been definitely placed for about 20,000 houses by special methods of construction, 5,000 of which were actually under construction, while contracts for nearly 18,000 more were under consideration. In addition, some 3,500 concrete houses were being erected by private persons with the aid of the Government subsidy.

So far the shortage and uncertainty of delivery of cement supplies have somewhat handicapped concrete construction, but we are assured that every effort is being made to secure a larger production, and that an increase on the pre-war output is confidently anticipated by the manufacturers in the near future.

A multitude of different systems of building small houses in concrete have been evolved and developed since the war, and approved by the Ministry of Health, mostly consisting of various types of shuttering for monolithic wall construction, solid blocks for forming cavity walls, and hollow blocks of various shapes. Many of these systems have been described in this journal, and we would emphasise the fact that the schemes dealt with each month during the past year are all actually being, or have been, carried out, some of them comprising hundreds of houses.

When it is considered that, except for a few experiments, concrete houses were almost unknown in this country before the war, the number at present under construction and under consideration can only be described as phenomenal.

When the very small sum needed for the maintenance of concrete houses is fully realised, we predict an even greater vogue and popularity for them.

CONCRETE ROADS.

Another application of the material, and one which promises a wide development in the future is that of concrete roads. This form of construction is steadily increasing in favour and has been adopted in several places during the year, among the most recent being those at Bath, Newbury, Southwark (where something like twenty-five streets have been paved with concrete) and in Northumberland.

LABOUR-SAVING DEVICES AND MACHINERY.

Another feature of the past year has been the improvement in labour-saving devices, especially block-making machines for both hand and power. Handy, efficient, and serviceable machines can now be obtained to suit either the contractor who requires a battery for a big scheme or the small builder who is putting up a couple of houses. We were told the other day by one such small builder that a hand machine he bought as an experiment for use in the erection of three houses had paid for itself on that job alone by the saving in labour—and he still had the machine in good condition. There is, we believe, a great scope for the more extended use of machinery on even small jobs, both in reducing the cost and expediting the work. For instance, small hand mixers (which can be adapted for power) can now be obtained for about £50, and not only is the capital outlay soon recouped by the saving in labour but better concrete is obtained than can possibly be the case when the mixing is done with a shovel. Elevators and gravity conveyors are also being more extensively used, and are proving their worth.

OTHER DEVELOPMENTS.

Although the past year has been chiefly notable for the development of concrete in the direction of housing, many large public buildings, factories, and warehouses have been erected in this material, and a notable event was the completion of the first large concrete office building in the City of London, namely, the eleven-storey Commercial Bank, in Gracechurch Street, from the designs of Mr. Gould Wills, A.R.I.B.A. The restrictions on so-called "luxury" buildings and high costs have affected the total number of large buildings erected, but concrete construction has not been so badly hit as other forms; in fact, in many cases local authorities have stipulated that new buildings shall be erected in concrete, in order to conserve labour which could be employed on housing.

If only a satisfactory agreement could be brought about with labour, so that a certain amount of stability could be attained and definite tenders submitted without vague provisions as to increases owing to unknown advances in wages and materials, the industry would go ahead at an even greater rate than at present, with advantage to the very large number engaged in the concrete and allied industries and the country at large.

THE MINOR USES OF CONCRETE.

During the past year, also, there has been a great expansion in the application of concrete to minor uses, such as fence posts, pipes, troughs, tanks, silos, poultry houses and pigstyes, and many firms realising the increasing demand have taken up the manufacture of such products. In spite of this, however, there is still room for contractors and others, who will take up this work and put upon the market such articles as people would rather buy than make for themselves.

The Railway Companies, too, have made continual progress, and during the past twelve months have considerably widened the scope of their concrete work. The London & South Western Railway Company, for example, have been so satisfied with a certain number of experimental telegraph poles which they have had in use for some time that they propose to adopt them very extensively on their system.

CEMENT PRICES.

A LONG and exhaustive report has recently been issued on Cement and Mortar by a Sectional Committee appointed by the Standing Committee on the Investigation of Prices and Trusts. It is satisfactory to note that while the financial position of the cement industry has substantially improved owing, in some measure, to its profitable export trade, no unreasonable increase in the home trade price has occurred, and that the trade therefore is acquitted of any suspicion of profiteering. It is pointed out that in the period and in the cases under review the percentage increases in the total costs of production are substantially more than the percentage increases in the average home trade selling prices. A reduction in cement prices is not anticipated unless the difficulties of fuel, labour and machinery replacements are overcome. Amongst other recommendations it is suggested that the existing voluntary limitation of exports should be continued so long as the urgent home trade demands are unsatisfied, and it is further suggested that the authorities should aid the trade by ensuring the necessary supplies of suitable fuel and providing the necessary transport facilities.

THE CONCRETE INSTITUTE AND THE INDUSTRY.

MR. FIANDER ETCHELLS' admirable Presidential Address to the Concrete Institute (reported in our last issue) might very well be summed up as a plea for good concrete and sound construction, by improvements in the three cardinal requirements necessary to attain that end—research, education and workmanship.

We have in these pages frequently urged that the work of the Industrial Research Board should be considerably extended, and we are glad to see that Mr. Etchells further ventilated this important matter. However, the Building Research Board is now in being, under the chairmanship of Mr. H. O. Weller, and its reports, which are expected to commence shortly, will no doubt contain much of interest and value to the industry.

Now that such large numbers of concrete houses are being built, Mr. Etchells' remarks on this subject are very timely. It can readily be conceived that the urgency with which the houses are required might be an inducement to some builders and contractors to use concrete which is not properly made or properly cured, but it must be remembered that no new industry can force its products upon the public, and this applies as much to concrete houses as to anything else. To obtain a secure footing they must be of the very best construction, and the demand in the future will be regulated by the quality of the houses now being built. The porous blocks mentioned in the Address are quite exceptional, and could only have been the result of bad workmanship or ignorant supervision, for as Mr. Etchells truly said : " If the sand fills all the voids in the coarser material, and the cement fills all the voids in the sand, where is the water to get through ? " That is the fundamental basis of good concrete, and if it is always graded so that there are no voids and an impervious aggregate used there will be no complaints of its not being weather-proof. We are convinced, however, that the vast majority of the concrete houses now being built all over the country by reputable contractors will be a credit to the material, and a source of satisfaction to their owners.

The suggestion for a special class of membership of the Institute for clerks of works, builders' foremen, and others engaged in a supervisory capacity is an excellent one, and one which we hope will be carried to fruition. The large amount of unskilled labour now engaged on concrete work makes it essential that those directly responsible for its supervision should be absolutely competent. It is no exaggeration to say that the success of any concrete, and especially reinforced concrete, building depends as much upon the careful mixing and placing of the materials as upon the accuracy with which the designs are followed. It is, therefore, of the utmost importance that the foremen should be efficient, and, provided that none but fully-qualified men who had passed an examination were admitted, the formation of a body of men with what would practically amount to a guarantee that they knew their job, and who could be unhesitatingly employed by contractors, would be a boon to the industry and, we believe, would be welcomed by the men concerned as giving them a better status.

In the latter part of his Address, Mr. Etchells referred to the arrangements for the acceptance as members of the Institute of Bachelors of Science, Bachelors of Engineering, Associates by examination of the Institutions of Civil and Mechanical Engineers and the Royal Institute of British Architects, officers of the Royal Engineers, "or the holder of such other degree or qualification as the Council may determine in specific cases." We should be inclined to go further and suggest that, in the best interests of the Concrete Institute, some form of examination or test should be imposed in all cases of future candidates for membership.

CEMENT SUPPLIES.

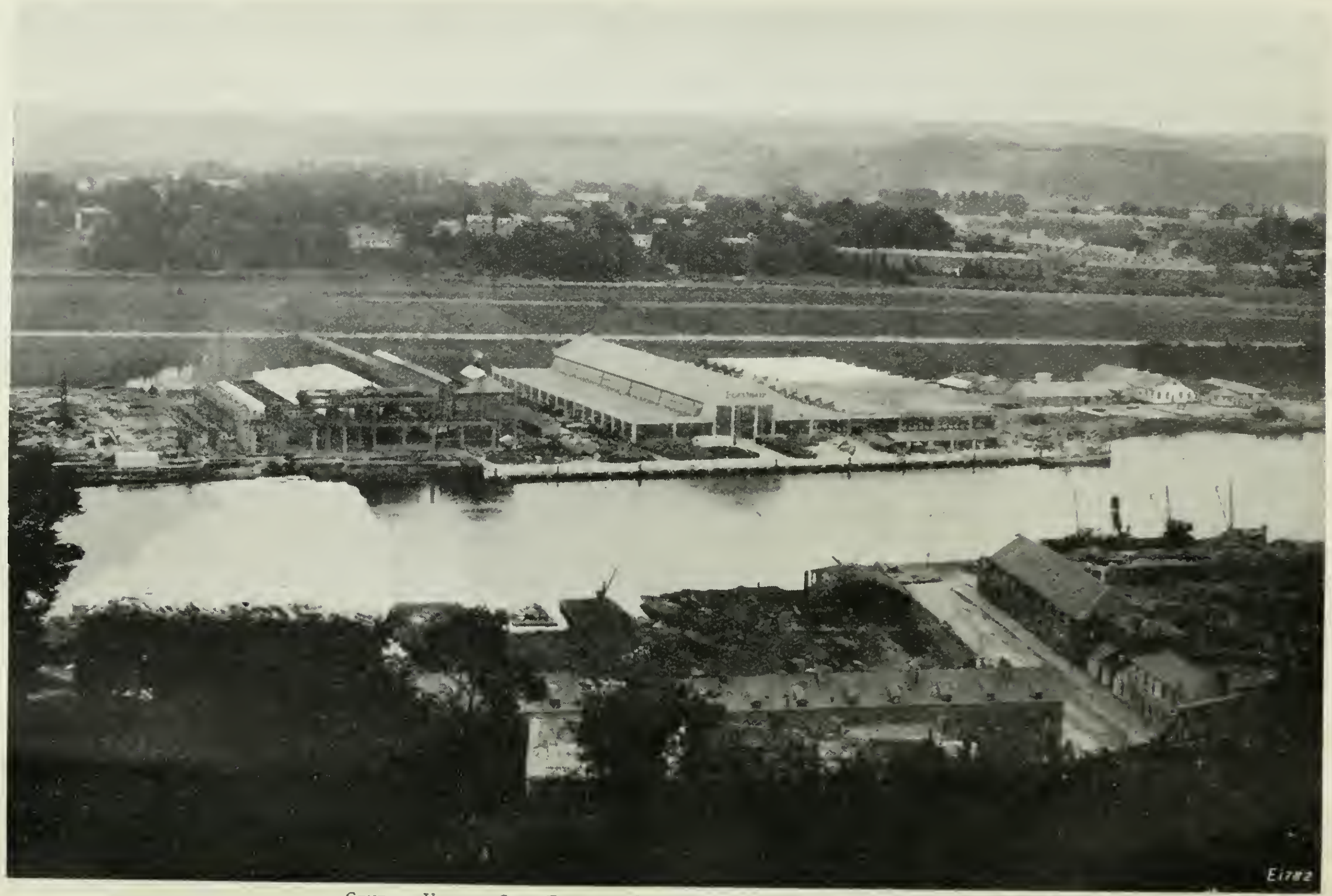
THE statements that have recently appeared in the press concerning an anticipated early increase in the supply of Portland cement is confirmed by the announcement of the Cement Marketing Company Limited made in another page of this issue.

This news will be received by the interested trades with considerable satisfaction, as the difficulties and delays in many districts regarding cement deliveries have recently been at times somewhat embarrassing.

It is generally recognised that the wide adoption of concrete for building and other purposes has been a feature of the post-war period and this development, arising at a time when there was an abnormal demand in connection with reparation work and housing, has undoubtedly added to the temporary difficulties of supply. Prior to the war it was possible to secure prompt deliveries of cement in any part of the United Kingdom, and this facility is, of course, necessarily all-important to concrete users. We are sure this point cannot fail to be fully appreciated by the manufacturers.

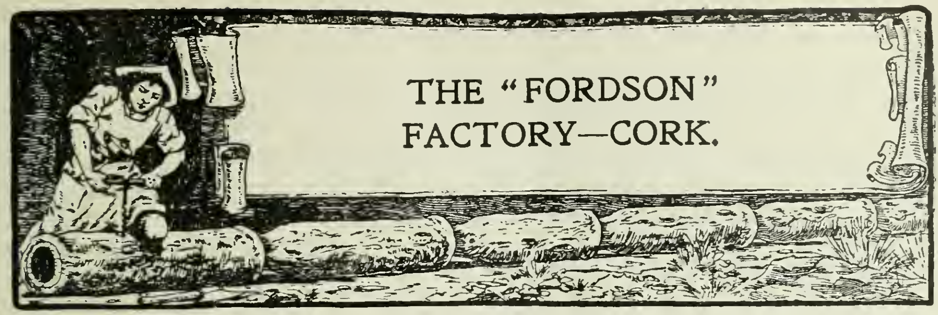
The present announcement of speedy relief in this direction from one of the principal sources of supply will, therefore, do much to remove what might otherwise have proved a serious objection to the adoption of concrete work in schemes under consideration. Given, however, assurance of adequate cement supplies, there will remain no serious obstacle (other than such as are general throughout the building trades) to the continually widening application of concrete to those purposes for which it is found to be pre-eminently suitable.

The further announcement of the Cement Marketing Company, Ltd., in regard to the resumption of forward contracts at definite prices should tend to add to the stabilisation of the Building Industry.



General View of Cork Factory, Henry Ford & Son, Ltd., Looking South.

(For description see page 5.)



THE "FORDSON" FACTORY—CORK.

By **H. C. JOHNSON**, M.C.I., Chief Constructional Engineer, Ford & Son, Ltd.

THE ground owned by the Company (Henry Ford & Son, of the Ford Interests) is still known as the City Park and the Site of the Cork Racecourse, being an area of 138 acres alongside the river Lee, a mile from the centre of Cork City and due east from it on the southern bank of the river.

It is favourably situated for both river and land service, a branch of the City Railways (which connects with all the broad gauge lines) entering the property, while boats up to 500 ft. long and with 24 ft. draught can lie alongside the wharf, a reinforced concrete structure originally erected for the Harbour Commissioners.

The actual turning of the first "sod" was in April, 1917, since which time 65,000 cu. yds. of earth have been moved to level the high portion of the site, a foundry, machine shop, 400 feet of retaining wall, offices, garage, canteen, shipping store and loading dock have been erected, the last five being temporary but well-built structures, while at the time of writing a power house is under construction.

Fig. 1, from a photograph of a model made to scale, shows the location of the various structures at this date, and is used each time further buildings are under consideration.

The original layout for the site called for a four-storey machine shop, but it was finally decided that only single storey buildings should be erected, thereby avoiding the hoisting and lowering of medium weight castings and obtaining better light and ventilation. This delayed the start of erection of the machine shop until January, 1919, but in the meantime the 65,000 yards of excavation and fill, the erection of the first portion of the foundry (now an insignificant part of the whole), temporary offices, garage, the retaining wall and odd sheds had been completed. Thus the greater part of the buildings shown in the general picture (*Frontispiece*) has been erected in twenty-two months.

The ground is at two elevations, the higher—about 450 ft. wide (measuring at right angles to the river)—being filled ground with a surface about 2½ ft. over high water, and the lower of alluvial soil, with a surface about 7½ ft. below high water, but 5 to 6 ft. above low water, thus allowing it to drain through double non-return sluices.

Foundations.—Both the higher (filled) ground and the lower (alluvial) ground is of a comparatively soft cheese-like nature and therefore no permanent buildings are erected without piles.

Piling.—The piling has been done by Concrete Piling, Limited, of Westminster, on their Cast-in-Place system. Piles have averaged about 24 ft. long from ground to point with minimum lengths of 20 ft. and maximum of 27 ft. and, where they have been exposed in some cases to a depth of 14 ft., are almost perfectly cylindrical. The carrying capacity has been varied from the Company's standard of 30 tons, determined by a penetration of not more than 1 in. for four four-foot blows of a two-ton hammer to 25 and 20 tons for $1\frac{1}{4}$ in. and $1\frac{1}{2}$ in. respectively, using the same hammer and drop. A 10 ft. long by $\frac{3}{4}$ diameter bar has been placed in the top of each to act as bonds for the pile caps. Pile groups of two to six have been used, with three-pile and two-pile groups predominating.

Pile Caps.—Pile caps have been kept with tops at one foot below the floor line, which is the same for all buildings and is 30 ins. over H.W.O.S.T. Their depths vary according to load and arrangement of piles in the group. Typical pile caps are shown in *Fig.* 2, together with method of design of a pile cap. In connection with this item the writer knows of no textbook which gives a design for pile caps except with a great number of piles such that conditions approximating to plain footings might be assumed in design. This method of design is shown in the hope that it will suggest a study of this important item by some of our technical writers, and that they will evolve a compact method of design. It will be noted that the ground is not taken as carrying any of the load, although in some cases the area covered by the cap is considerable and it is because the soil is of a jelly-like nature, which causes the pile tube to rebound several inches after a blow of the hammer until the point reaches gravel at about 14 ft. on the low ground. The high ground, being composed of town rubbish of a very mixed and poor type, is little better. It has, however, one redeeming feature in the large amount of tin scrap punchings, which more or less "reinforces" the ground and thereby greatly reduces the amount of shoring to excavations—none being required for six feet. Because of this poor ground nearly all concrete flooring is reinforced, in some cases in both top and bottom layers.

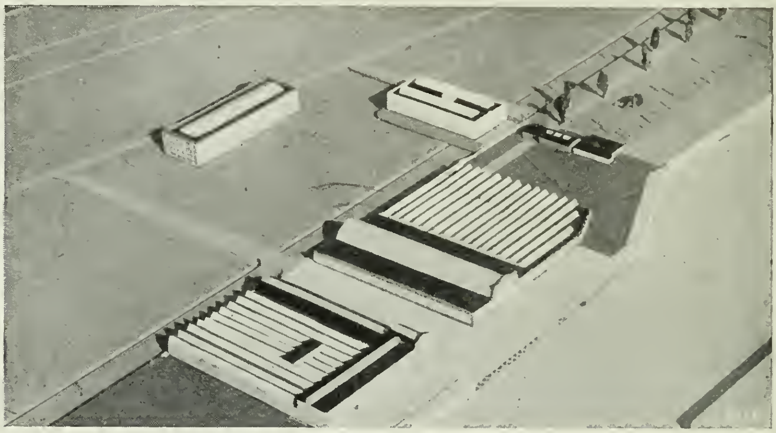


Fig. 1. Photograph of Model to Scale.
THE FORDSON FACTORY, CORK.

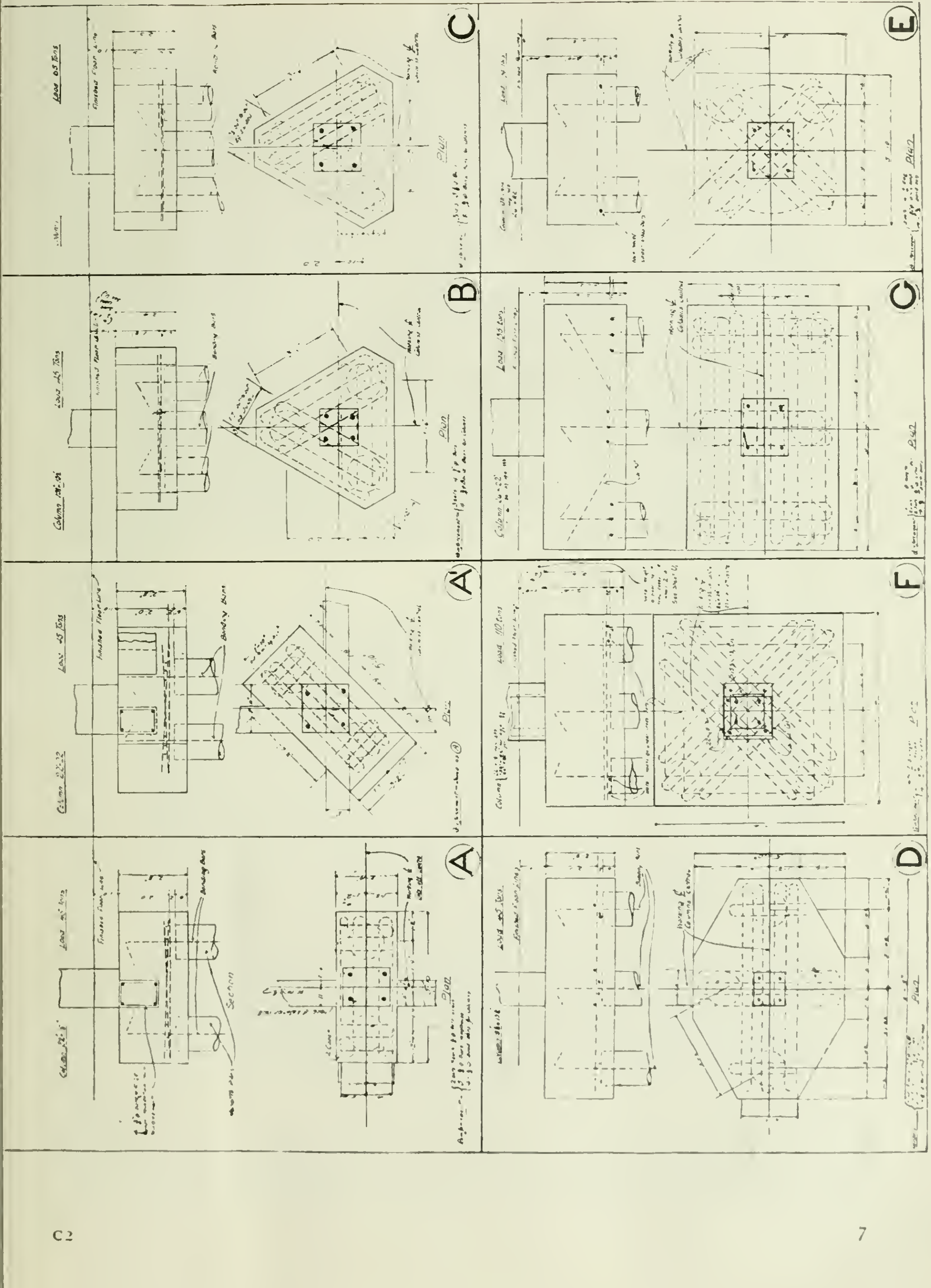


Fig. 2. The Pile Caps.
The Fordson Factory, Cork.

PILE CAP DESIGN.

Typical 3-Pile Group.

Load	45 tons	101,000 lb.
Depth for Punching Shear	$\frac{101,000}{4\times18\times100}=14+2+6$	22″
Depth for Bond Bars	30 dia. of ¾ bar $=22\frac{1}{2}+6$	$28\frac{1}{2}$
B M Considering Cap as 3 beams of width equal to pile dia. equal to 16″; each spanning pile centres; and taking load conditions on each as average between concentrated and uniform distribution.	$\frac{101,000\times42}{3\times5\cdot3}$	266,000 lb. in.
Depth by B M	$\sqrt[2]{\frac{266,000}{111\times16}}=15+2+6$	23″
Depth for Diagonal Tension	Does not govern.	
Steel	$\frac{266,000}{\frac{7}{8}\times20\times12,000}=1\cdot26$ Bond bars fix top of pile $22\frac{1}{2}''$ making D $=20''$	4—⅝″ bars
Bond Stress Average	Area bars $4\pi\times\cdot625=7\cdot9$ Bond $=\frac{4\times\cdot31\times12,000}{7\cdot9\times31}$	61 lb. per ″
Make Cap	As shown.	

Foundry—First Portion.—This was the first permanent structure erected and is a steel building clothed with brickwork, 238 ft. long by 50 ft. wide and 38 ft. to underside of trusses; the northern 38 ft. is of two storeys, the upper floor being charging floor for the cupola. There is nothing of special interest in this structure.

Machine Shop—First Portion.—This building is the finest, structurally, in the group and is distinguished by its central glass roof portion, the craneway 50 ft. wide, on each side of which are two spans of 33 ft. with a length of 352 ft. (16 bays of 22 ft.), a width of 188 ft. and nearly 60 per cent. of its exterior surface glazed. It has excellent light inside at any point. See *Figs.* 3 and 4.

The general arrangement is shown by *Fig.* 5, and the outstanding feature is the trussed type of crane girder with diagonal members in compression instead of being reversed and being placed in tension, the principal reason being that a greater shear (vertical) area is obtained with smaller section members, causing less obstruction of light than the latter condition would give. All roof

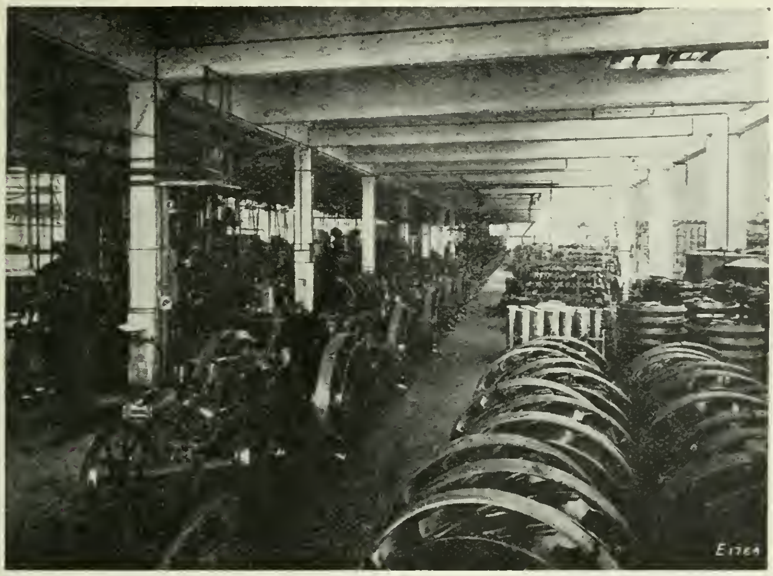


Fig. 3. Tractor Assembly Conveyor and Stock Storage as seen from south end of Machine Shop.
(Highest Output to Date—50 Tractors per 8 Hours.)

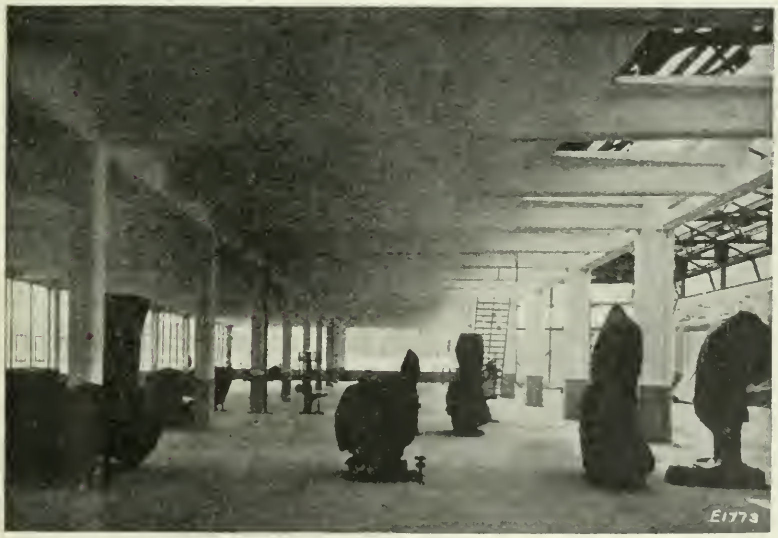


Fig. 4. Machine Shop.
The Fordson Factory, Cork.

glazing by Mellowes & Co. being of lead-covered bars, while the sashes by the Crittall Manufacturing Co. are Fenestra section steel.

Machine Shop—Second Portion.—A change was made in the type of construction for this addition by using northern sawtooth lights. *Figs.* 6 and 7 show this structure. The roofing material on the southern slope is " Everite " corrugated cement asbestos on purlin centres, rather greater than suggested by

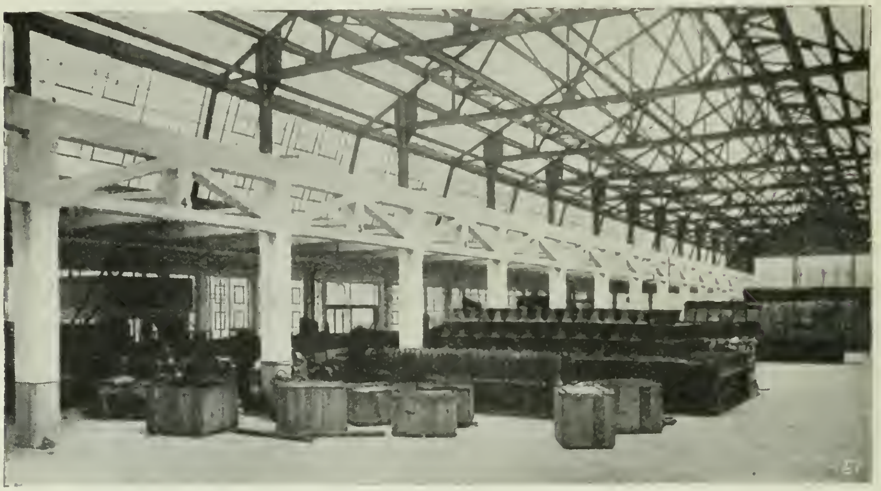


Fig. 5. Machine Shop Craneway.

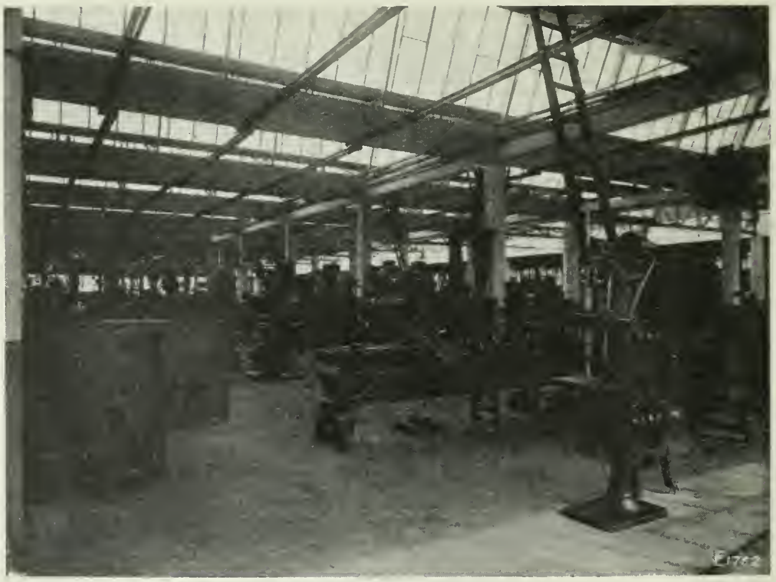


Fig. 6. Machine Shop Extension.
The Fordson Factory, Cork.

the makers, being up to 4 ft. 2 ins., this spacing being more economical than anything less in spite of possible smaller sections. The glazing in this case being also by Mellowes & Company.

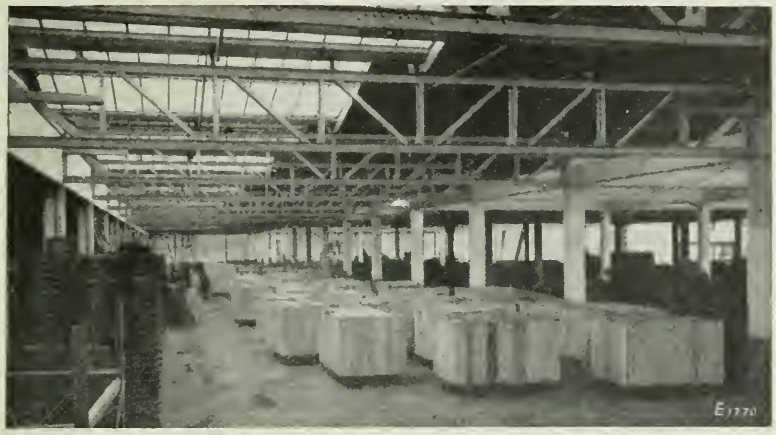


Fig. 7. Machine Shop Extension. (Shows Tractors Crated for Roumania.)

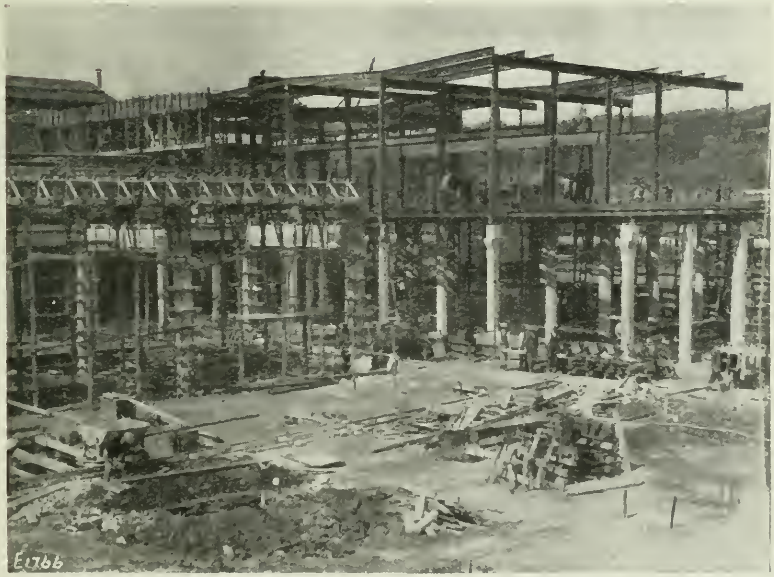


Fig. 8. Foundry Extension. Looking N.W. shows Octagonal Concrete Columns to Cupola Charging Floor.
The Fordson Factory, Cork.

It will be noticed that a departure from the usual truss form of sawtooth is made, and for three reasons :

(1) Delivery of the steel was quicker.

(2) Members could not be bent in shipping, as would most likely have been the case with lightly built trusses, and

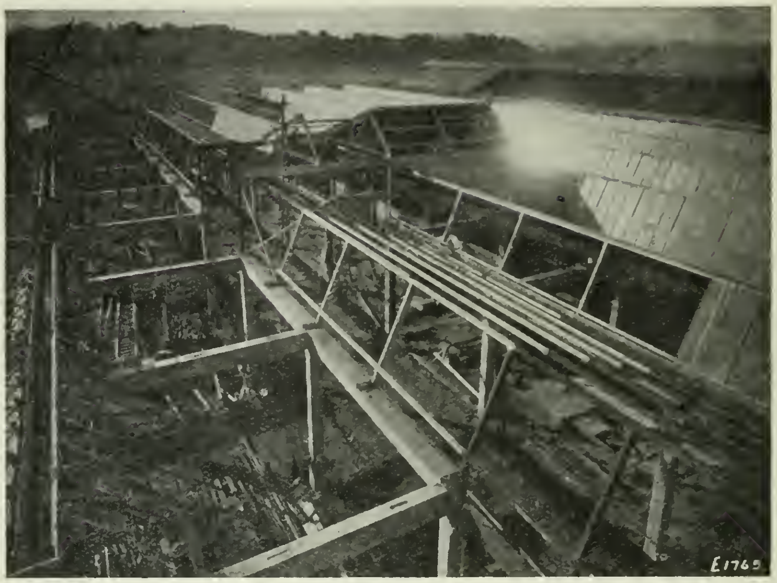


Fig. 9. Foundry Roof Looking south-west. (Shows Simple Roof Trusses.)

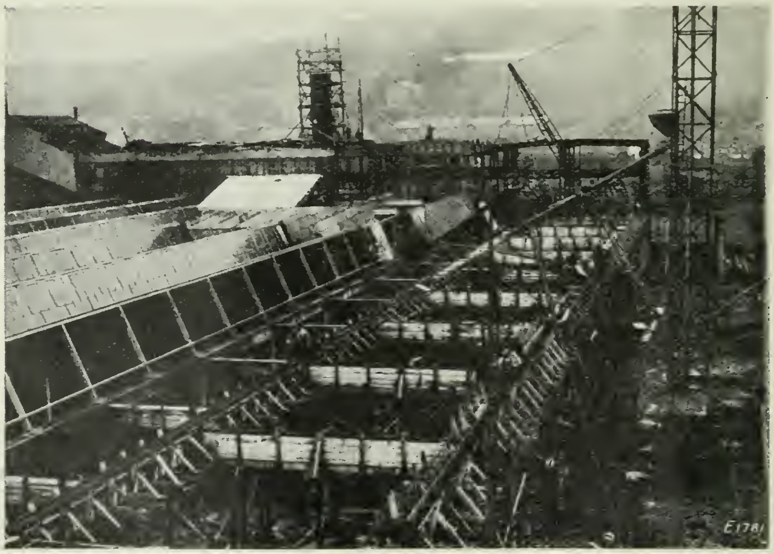


Fig. 10. Foundry Extension. (Showing Concreting Tower and one of four Cupolas.)
THE FORDSON FACTORY, CORK.

(3) The appearance is better, while the web-like maze of truss members is avoided. The same type of steel sash is continued in this building.

Provision is made for the continuation of the shop by running the beams half-way on what are now the exterior columns, which are somewhat wider than the interior columns in consequence.

Foundry—Second Portion.—This portion will increase the building to 345 ft. × 270 ft. or eight times the old foundry area.

Except for the high or two-storey northern section, in which four additional cupolas will be placed, the building is of the same general type as the second portion of the machine shop, except that bays are 24 ft. × 22 ft. instead of 33 ft. × 22 ft. and that the sawtooth glazing is toward the east instead of the north.

The high (two-storey) portion is the more interesting structurally, since a number of unusual features have been adopted. These tabulated are as follows :—

(1) All first storey columns are of octagonal spirally reinforced concrete, the largest being 21 ins. in diameter to carry a load of 110 tons.

(2) The floor beams are not bolted to the girders, which are not holed except in the bottom flanges, and only at columns, but extend beyond the double girders and held by a plate clip, using two bolts. If the girders had been holed in the top flanges, the next heavier section would have been necessary, due to loss of flange section. Furthermore, alterations take place so rapidly—due to new factory methods—that it is inadvisable to finally locate and fix any member of a floor system.

(3) The steel roof beams are similarly treated, except that they butt on the centre of single girders with a connecting plate under and between them and the girder, while the plate clips and bolts occur on both sides of girder flange.

Figs 8, 9, 10, show the general scheme.

(4) Bins for sand and coke run the entire length of two bays with a capacity of 100 tons per 22 ft., giving a total of 1,000 tons.

(5) While steel plate floor is being placed in front of cupolas, the remainder of the floor is being covered with 1½ in. concrete slabs, approximately 3 ft. square. Floor loads of 800 and 250 lb. per sq. ft. are provided for in front of cupolas and elsewhere respectively.

(6) The portion of roof over the bins is made of alternate sliding and fixed sections to allow for charging the bins.

(7) The landing platform for pig and scrap iron on northern front has a floor of channels placed with webs horizontal and flanges down and ¼ in. apart, thus preventing accumulation of water (having no roof) and eliminating a steel plate floor.

The writer proposes to write later on the Construction Methods, Forms, Concrete Proportioning, Tests, Concreting Tower and Chute.

All the buildings have been designed by the writer and members of his department, a number of whom are graduates of University College, Cork, and it is a pleasure to state that in carrying out the work by direct labour, all concerned—including workmen—are most interested in and proud of their work. Labour here is very willing and adaptable, which in a large measure induced the Company to locate in Cork.

SHEARING STRESSES IN RECTANGULAR REINFORCED CONCRETE BEAMS.

By ALFRED FYSON, M.Inst.C.E.

While we have much pleasure in publishing the following thoughtful and original article, it must not be supposed that we are in agreement with the conclusions arrived at, and, in point of fact, we shall be publishing some comments on the article next month which go to show that the majority of specialists have, as a result of their experience, come to somewhat different conclusions.—Ed.

Before any part of the material in a reinforced concrete beam is ruptured by flexure, all the strains and stresses and the value of its transverse resistance can be deduced from and are subject to the same laws as those which govern an ordinary beam of homogeneous material, for like statical conditions and mechanical properties are common to both; after the concrete in tension becomes ruptured to such extent that the internal shearing stresses become undefined, speculative or unknown, those conditions and properties no longer hold and the "true" functions of a beam are lost; beyond such point then it is not intended to carry these investigations.

The method usually employed for finding the value of the transverse resistance of a beam, either in a sound or ruptured state, is to neglect the effect of the concrete deemed to be in tension and to suppose the whole of such stress as taken up by the reinforcement; the reasons generally alleged for thus eliminating the tensile value of the concrete being its somewhat small resisting power, compared with that of the material in compression, and the suddenness with which it breaks. Whatever degree of approximation to the actual resistance of a beam may be produced by formulæ founded on this "elimination theory," they are certainly incapable of determining, even approximately, any of the actual strains and stresses induced by flexure; such theory and formulæ will not be employed herein, for the following investigations demand that all the necessary strains and stresses shall be accurately determined; therefore, the required results must be obtained by rigorous mathematical treatment; the concrete in tension will be made to take its due share of work, and all the material will be supposed to be, and to remain in, a perfectly sound state throughout. The computation of the external shearing forces on a beam—whether simply supported at one end only or at both ends—is a matter which presents no difficulty; but the opposing internal shearing forces and the stresses induced by them are founded on complex and intricate statical and mathematical principles; the main results only of those principles will be dealt with here, and in a manner as simple as may be found necessary for their proper comprehension.

In a solid beam of rectangular section and homogeneous material, the internal shearing stresses are but seldom considered in its design, for those stresses are generally well below the ultimate shearing strength of the material itself as found in ordinary practice; but in a beam of reinforced concrete those stresses may possibly be the factors which tend to determine its absolute strength. Shearing stresses at a section may be divided into two kinds, the one of constant and the other of varying intensity; the latter kind is induced when a beam is under the influence of varying bending moments, and is the only one which it is necessary to consider here.

A familiar method of illustrating the effect of shear in a beam, which is often found in textbooks on the subject, is that of two or more superimposed planks ; and it may be briefly described as follows :—Suppose two planks, say of the same scantling, the first one merely supported at its ends and the second one resting on the first along its entire length, *Fig.* 1.

At the junction of the touching surfaces somewhere between the centre and a support, let there be marked two arrow heads, the one opposite the other on each plank. Now let a load W be placed anywhere on the top surface, say at the centre ; the two arrow heads will become separated owing to the extension of one touching surface and the shortening of the other, *Fig.* 1A. Suppose W to be removed and keys or dowels to be closely fitted into notches cut in the planks ; on W being again imposed, the arrow heads will remain in their original positions, the one opposite the other, *Fig.* 1B. The addition of the tightly-fitting keys has caused the two touching surfaces to act together as only one, and that is due to the " shear " resistance offered by the keys.

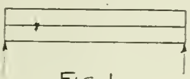


FIG I

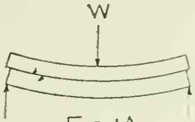


FIG I^A.

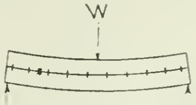


FIG I^B

It is required to determine how such shear is produced, and its nature and intensity at any point in the length and depth of a beam.

Theoretical determination of Shear.—Let *Fig.* 2 represent part of a side elevation of a beam simply supported at the ends and loaded somewhere on the top with a weight W, the reaction of the left-hand side abutment being P as due merely to W, for the weight of the beam itself is here assumed to be neglected. Let the beam in this instance be supposed to consist of some homogeneous material without any reference to reinforcement, its section being rectangular, the depth and breadth each being supposed equal to unity.

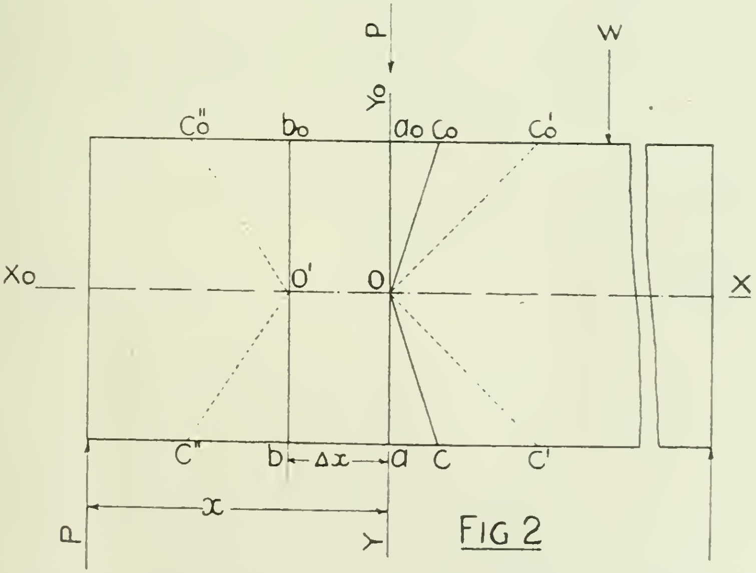


FIG 2

Let the line X_0X be the geometrical axis of the beam ; let it also represent the position of the plane of the neutral axis along it ; and let the line YY_0 be drawn normal to X_oX, cutting it at the point O. Suppose two sections to be taken, the one at aa_o on the line YY_o, and the other parallel to it at bb_o, the distance apart of the two sections being some small but tangible length ; and let the figure abb_oa_o represent a solid slice or strip through the breadth of the beam.

For simplicity suppose the internal horizontal stresses due to flexure to be uniformly and similarly varying for both tension and compression. Now the bending moment due to P is greater at the section aa_o than that at bb_o, consequently the resisting forces or internal horizontal stresses acting against the back of the solid strip at aa_o, are in excess of those acting against the face at bb_o. Let the horizontal distance from the back of aa_o to the left support be called x, and the length of the solid strip from face to back be Δx.

The bending moment at $aa_o=Px$ . . . . (*i*)

The moment of resistance required to balance Px may be represented by forces or stresses enclosed by the two triangles Oac', $Oa_oc'_o$; the former being for tension and the latter for compression.

The bending moment at $bb^o=P(x-\Delta x)$ . . . . (*ii*)

The forces at the section bb_o resisting that bending action are represented by the two triangles $O'bc''$, $O'b_oc_o''$, respectively for tension and compression.

The forces acting against the back aa_o in excess of those acting against the face bb_o are evidently the differences between the forces in the triangles Oac', $O'bc''$ and $Oa_oc'_o$, $O'b_oc''_o$; those excess forces are due to the bending moment.

$Px-P(x-\Delta x)=P\Delta x$ . . . . (*iii*)

and are represented by the triangles Oac, Oa_oc_o ; from those excess forces the nature and intensity of the internal shears will be deduced. So far no actual values have been ascribed to the forces acting against the sections at aa_o and bb_o as Δx has no numerical dimension assigned to it, nor is any such dimension absolutely necessary, as merely relative values of the resisting forces will suffice ; in the diagram *Fig.* 2 those relative values will be of the same ratio to each other whether Δx be made sensibly dx, or the full length x.

This employment of a hypothetical solid strip, in order to demonstrate the action of the horizontal direct stresses in determining the internal shearing forces and stresses, is the method used by Rankine.

Let the solid strip abb_oa_o, shown in *Fig.* 2 be considered as in a free state, *Fig.* 3, and let its general statical conditions be examined. The forces holding the strip in equilibrium are, an upward force P acting through bb_o, a downward force of like amount acting through a_oa, and the excess forces or stresses represented by the triangles Oac (tension) and Oa_oc_o (compression) acting normal to the back aa_o.

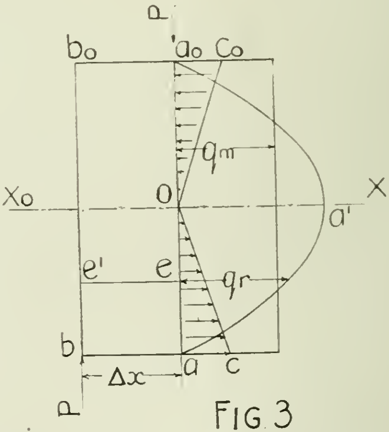


FIG 3

Those various forces cause certain other forces or stresses through and on the solid strip, some of which have to be determined.

From any point e on the line aO suppose a plane ee' through the solid strip and parallel to the axis XX_o ; the horizontal force or " pull " exerted by the excess forces in the triangle Oac against that part of the strip lying between a and e tending to slide it along the plane $e'e$, is there resisted by the cohesion of the material, and that cohesion is the horizontal shear at that plane.

Let the sum of the forces in the triangle Oac which are acting against the strip from a to e be found and plotted as an ordinate q_r at the point e on the line aa_o as base; then q_r represents the horizontal shear at the plane $e'e$.

In like manner let the horizontal shears at other planes through the solid strip from a to a_o be calculated and plotted. By joining the ends of the ordinates so found the curve $aa'a_o$ of q_r's is obtained. The forces in the triangles Oac, Oa_oc_o may be summed either from a or a_o as origin, but whatever sign is used to commence with must be changed at the neutral axis, as the forces there alter from tension to compression, or vice versa.

Suppose the summing to be commenced at a, then $q_r=o$ at the origin. Midway between a and O, q_r=three-fourths of the area Oac; at O, q_r=the area Oac; midway between O and a_o the ordinate q_r=the area Oac less one-fourth of the area Oa_oc_o; and at a_o, q_r=the area Oac less the area Oa_oc_o that is=o. In the present instance the curve $aa'a_o$ of q_r's is evidently a parabola and its ordinates represent the horizontal shears at all points throughout the solid strip from a to a_o.

A simple method for finding the internal horizontal shears having thus been described, it is now necessary to determine the corresponding internal vertical shears, and they depend on the following principle :—"The intensities of the tangential stresses at a given point on a pair of planes at right angles to each other and to the plane parallel to which the stresses act are necessarily equal" (Rankine). Therefore the curve $aa'a_o$ of q_r's not only serves to give the values of the horizontal, but also those of the vertical shears at the same points. Those values which will now be called "relative," as they may not always be actual values, must be transformed into real intensities of the tangential stresses; and it will be necessary to take into consideration not only the value of P acting at the required section, but also in a general sense the depth H and breadth B of the beam at that section.

In *Fig.* 3 let the solid strip abb_oa_o be supposed to act as if it were still a part of the beam as in *Fig.* 2. The total vertical shear can only be that due to P, and as the relative values of the horizontal and vertical shears at the section aa_o are identical and each kind is represented by the curve of q_r's, so by putting the area of the figure $aa'a_oa$ equal to $P \div B$ will those relative values be changed into real values, and when the depth H is taken into consideration the actual intensities of the tangential stresses at all points of the section will be given. Let such intensity of the tangential stress at any point be called q and let the mean value of the q_r's be called q_m. In *Fig.* 3 the curve $aa'a_o$ is a parabola, Oa' is equal to $3q_m \div 2$, and aa_o is equal to H; hence the following identities are found :—

$$\left.\begin{array}{ll} \text{The area of } aa'a_oa=\tfrac{2}{3}(Oa'\times aa_o)=\dfrac{P}{B} & \cdots\cdots \\[2ex] \text{As } Oa'=\dfrac{3q_m}{2} \text{ then } q_m=\dfrac{P}{BH} & \cdots\cdots \\[2ex] \text{Now } q : \dfrac{P}{BH} : : q_r : q_m & \cdots\cdots \end{array}\right\} \cdots\cdots \quad (iv)$$

$$\text{Whence } q=\frac{Pq_r}{BHq_m} \quad \cdots\cdots \quad (1)$$

The maximum intensity of the tangential stress is at the neutral axis, and when the curve of q_r's is a parabola its value is generally expressed as $\frac{3}{2}$ that of the mean intensity on the entire section. When therefore, q_m is once found it is seen that any required q can be easily determined.

Algebraic formulæ could readily be given for finding the value of any q, and they would be simple expressions for the elementary example just described; but such formulæ would not apply to reinforced concrete, where although the general method of determining the stresses is similar to that given in detail above, the particular formulæ defining them would be somewhat different and more complex.

Reinforced Concrete Beam.—As the computation of the shearing stresses in a beam of reinforced concrete is then not so simple as for a beam of homogeneous material, it has been thought expedient to compute in practical and numerical detail those stresses as deduced from an actual example, the required formulæ and symbols being supplemented by their proper numerical equivalents.

The beam chosen for example is shown in section, *Fig.* 4 ; other general particulars not there given are—length over all, 10 ft. ; span, 9 ft. ; weight, 900 lb. ; age when tested, four months.

This beam was one of several tested by Dr. Oscar Faber, and was described by him in *Concrete and Constructional Engineering*, of May, 1916 ; it is chosen here because some of the tests appear to be well suited for these present requirements.

One of the tests made was for the purpose of discovering at what load the first ascertained crack appeared, that is when the concrete was first ruptured by tension ; that rupture apparently occurred when the load applied at the centre of the beam reached 4,100 lb.

The bending moment at the load, including the moment due to the weight of the beam itself, would be nominally about 127,000 inch lb., but the beam did not rest on " knife edges " nor on frictionless supports ; making some allowance for the lack of such conditions and also for the fact that the first rupture sometimes takes place before it is observed, the following particulars in (2) may be assumed as approximately correct when the first crack in the concrete actually occurred.

$$\left\{\begin{array}{ll}\text{Bending moment at the centre of the beam} & 117{,}000 \text{ inch lb.}\\ \text{Outside shearing force at the centre of the beam} & 4{,}100 \div 2 = 2{,}050 \text{ lb.}\end{array}\right\} \quad (2)$$

The computation of the internal stresses may prove to what extent—if any— this outside shearing force of 2,050 lb. contributed, by its induced shearing stresses, to the first rupture of the concrete.

Moment of Resistance of the Beam (*Fig.* 4).—From what has been previously expressed as to the resisting effort of a beam subjected to flexure, it may be correctly inferred that all the material in it will be made to yield its natural resistance, and that all the internal horizontal stresses throughout the depth of the beam will enter implicitly into the calculations. Therefore, the whole of the concrete in tension will be subjected to strain, as a proper appreciation of the shearing stresses and others depending on them cannot be otherwise obtained.

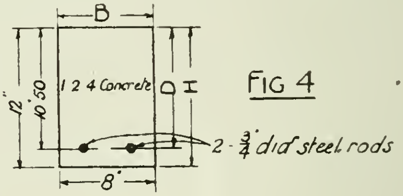


FIG 4

The method adopted for finding the moment of resistance at some required section of the beam is—with some slight modifications—in accordance generally with that described in *Concrete and Constructional Engineering*, Vol. viii., Nos. 5, 6 and 7 ; the details of the calculations will not be given herein, but only those results defining the internal horizontal stresses, and other particulars which will be required subsequently : thus in (3) will be found the maxima stresses relating to the moment of resistance necessary to balance the bending moment of 117,000 inch lb. as given in (2) ; those maxima stresses are believed to be in close accordance with reality, but some moderate difference either more or less, would not affect the explanations of the general principles involved. The following particulars relate principally to *Fig.* 5, and to the moment of resistance of 117,000 inch lb. :—

Concrete in compression . . .	f_o	625 lb. per sq. in. . . .	a_oc_o
Concrete in tension	f	295 lb. per sq. in. . . .	ac
Reinforcement in tension . .	f_s	5840 lb. per sq. in. . . .	
Sectional area of reinforcement	A_s	0·8836 sq. in.	
Position of the neutral axis .	h_o	5·80 inches from top of beam.	

f, f_o, f_s . . . any horizontal stress at lb. per sq. in. respectively for the concrete in tension, the concrete in compression, and the steel reinforcement in tension. (3)

Practical Determination of Shear. Beam (*Fig.* 4).—The diagram *Fig.* 5 is a part side elevation of the beam, the transverse section under consideration being on the line YY_o, its neutral axis being at O through which is drawn the horizontal line X_oX.

In what follows with respect to the formation of the curve of q_r's, the aid of the solid strip as in *Figs.* 2 and 3, will not now nor hereafter be further employed ; the actual horizontal stresses which are acting at the section, and which constitute the moment of resistance necessary to counterbalance the bending moment there, will be substituted for the previously undefined horizontal stresses which were supposed to be acting against the solid strip. Such method is theoretically and practically correct in a beam where the stresses are uniformly varying and may be taken to be if not theoretically yet practically correct in a reinforced concrete beam in which the stresses are not uniformly varying. In the figure, the weight of the beam between the line of action of P and the section at aa_o is supposed to be neglected.

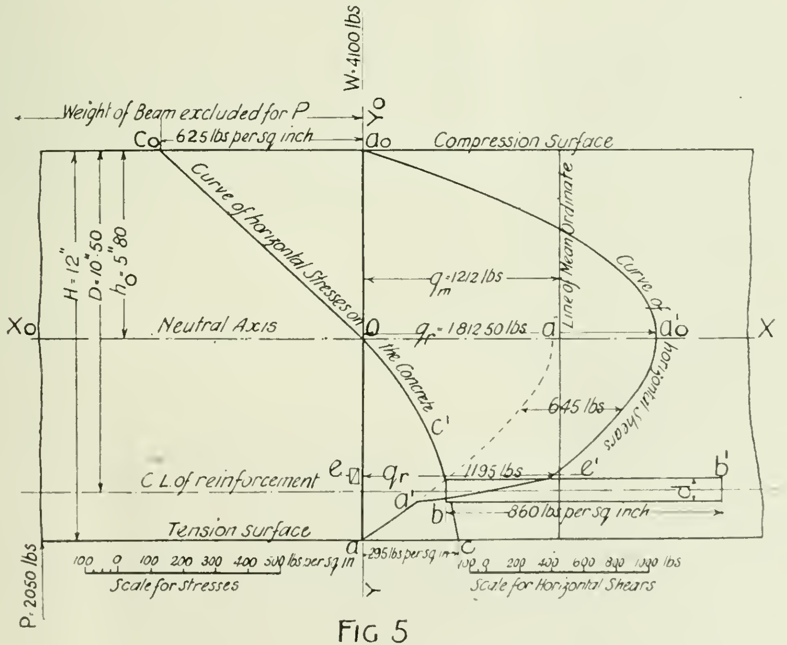


FIG 5

In *Fig.* 5 the horizontal stress intensities are represented by ordinates drawn from the base line aa_o to the curves Oc_o and $Oc'c$, the former for the concrete in compression, the latter for that in tension ; the stress intensity for the reinforcement is represented by the rectangle bb' the depth of which is $\frac{3}{4}$ inch, that being d the diameter of each rod. In the diagram the stresses on the concrete are those due to each one inch breadth of beam, and in order to make the total stress on the reinforcement conform also to that breadth it must be averaged by dividing it by B. The geometrical centre of the reinforcement is supposed to be also the centroid of strain.

$$\therefore \text{ Length } bb'=\frac{f_sA_s}{dB}=\frac{4(5840\times0\cdot8836)}{3\times8}=860 \text{ lb. per sq. inch} \quad . \quad . \qquad (4)$$

All the horizontal stress intensities are now complete for the construction of the curve of q_r's, but for certain reasons which will appear subsequently, the effects due to the concrete in tension will be kept distinct from those due to the reinforcement.

Suppose the summing of the stresses to be commenced at a_0. As Oc_0 is drawn in as a straight line—its real divergence from a straight line being too small for practical purposes—the stresses in compression are therefore uniformly varying, and the relative value of the horizontal shear at the neutral axis is

$$q_r=\frac{f_0h_0}{2}=\frac{\overline{a_0c_0}\times h_0}{2}\times\frac{625\times5\cdot80}{2}=1812\cdot50 \text{ lb.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (5)$$

Plotting that quantity it is represented by the ordinate Oa'_0; the remainder of the curve of q_r's between O and a_0 is easily drawn in as it evidently forms part of a parabola.

Next, commencing at a for the stresses on the concrete in tension and successively summing the ordinates to the curve $cc'O$ from a to O, the q_r^1's so found and plotted are delineated by the curve $aa'a''$; lastly the area of the rectangle of stresses—that is 860 lb. $\times\frac{3}{4}=645$ lb.—due to the reinforcement is added to the curve $aa'a''$; the value of any q_r for total " tension " effects is then given by an ordinate to the curve $aa'a'_0$ its base being the line aO.

The method of summing the stresses from separate origins has certain advantages in the present instance and is in general perfectly correct, for the total stresses in compression must balance those in tension; in the present case each total quantity is represented by the same ordinate Oa'_0. The actual intensities of the tangential stresses at any points in aa_0 can now be determined after q_m has been computed. For the beam under consideration the value of q_m—that is the mean ordinate of the curve $aa'a'_0a_0$—is thus found:

$$q_m=\frac{\text{area } aa'a'_0a_0}{\text{length } aa_0}=\frac{14{,}544}{12}=1212 \text{ lb.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (6)$$

The value of q_r at the neutral axis is given in (5) as 1812·50, consequently the intensity there of the tangential stress is, by equation (1):

$$q=\frac{Pq_r}{BHq_m}=\frac{2050\times1812\cdot50}{8\times12\times1212}=31\cdot93 \text{ lb. per sq. inch} \quad . \quad . \quad . \quad . \qquad (7)$$

In a similar manner the stress intensities at other points in the depth of the beam may be computed, but near to the reinforcement there is a local concentration of stress set up, which in some cases might prove to be of importance, as will now be shown.

Local Concentration of Stress.—On the line ee' *Fig.* 5, just above the reinforcement the q_r to the curve $aa'a'_0$ is found to be 1,195 lb.; it is divisible into two parts, one of which is due to the concrete alone and equals 550 lb., and the other is due to the reinforcement alone and equals 645 lb.

From equation (1) the stress due to the whole amount of 1,195 lb. is:

$$q=\frac{2050\times1195}{8\times12\times1212}=21\cdot05 \text{ lb. per sq. inch.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (v)$$

$$\left.\begin{aligned}&\text{The stress due to concrete alone then}=\frac{21\cdot05\times550}{1195}=9\cdot69 \text{ lb. per sq. inch}\\&\text{The stress due to reinforcement alone then}=\frac{21\cdot05\times645}{1195}=11\cdot36 \text{ lb. per sq. inch}\end{aligned}\right\} \quad (vi)$$

Now the stress—11·36 lb. per sq. inch—due to the reinforcement is the average stress as if taken over the full breadth of beam; it seems reasonable to suppose, however, that there must be a greater intensity of stress just over the rods than at the extreme sides of the beam. The precise determination as to the actual distribution of those stresses over the breadth of the beam depends no doubt on the spacing, size and form of the reinforcement; it is a matter of considerable complexity, and will not be attempted here; but from certain calculations which have been made for present purposes it would appear that for the beam under examination the maximum intensity of the shearing stress just over each rod as due to reinforcement alone is about twice the mean intensity as if taken over the entire breadth of beam.

Therefore, just over each rod the maximum shearing stress on the concrete would be, from (*vi*):

$$q = 9{\cdot}69 + (2 \times 11{\cdot}36) = 32{\cdot}41 \text{ lb. per sq. inch} \quad \ldots \ldots \quad (7\text{A})$$

It is thus seen that a local concentration of shearing stress intensity has been set up at the reinforcement which is greater than that found at the neutral axis in (7).

(*To be concluded.*)

THE TALLEST ALL-CONCRETE BUILDING IN THE WORLD.

A BUILDING of great interest to reinforced concrete engineers is now being erected at the corner of Frankfort and Gold Streets, Manhattan, N.Y.

Standing in the heart of the Leather District, it is to be a modern up-to-date office building, seventeen storeys high.

It is being built for the Hide & Leather Realty Co., a real estate association formed by a few prominent leather merchants, desirous of procuring comfortable quarters for themselves and at the same time providing suites of offices for other companies in the vicinity. This structure will provide a turning point in the history of architecture and reinforced concrete engineering, as it is the first high office building to be built entirely of concrete, both as regards interior frame and exterior walls.

The facing, instead of consisting of brick or stone, is concrete, a radical change from customary practice for a building of this type. When completed, it will have the distinction, we understand, of being the tallest all-concrete building in the world.

There are several new and interesting features in its construction, and it will probably be the Mecca of reinforced concrete engineers throughout the United States.

Our illustration on page 34 will give a good idea of the artistic appearance of the building, and shows what can be done architecturally with concrete.

Messrs. Thompson & Binger, Inc. of New York and Syracuse, are the designers, engineers and constructors of the building.

CONCRETE COTTAGE BUILDING.

HOUSING AT LIVERPOOL.

The question has been asked from time to time, why is it not possible to organise house production on the same broad comprehensive lines that made it possible during the war suddenly, not only to produce munitions for our own vast army, but also, to some extent, for those of our allies. There are many reasons why it is not altogether possible to organise for production in peace time with the equal speed and intensity that can be maintained in a time of great national danger. Moreover, in time of war, economy is a matter that must always be sacrificed to expedition. There is, however, no reason why some of the methods of organisation that were everywhere employed on large constructive works should not—with certain adaptations—be employed with success on housing schemes of sufficient magnitude to make such methods possible.

At Liverpool the opportunity exists, and advantage has been taken of it. The first contract on the Garston estate is for 2,000 houses to be completed by the middle of 1922, and this is to be followed by a further 4,000, covering in all more than 500 acres. The contractors are the Economic Building Corporation.

The work was begun in June of last year, and in spite of the bad weather of July and August the contractors claim to be ahead of the scheduled time. When building was begun it was with twenty-two men, and £10,000 were spent in the first four weeks. The number of men has now increased to nearly 1,100 and the amount spent to £25,000 to £30,000 each week.

ORGANISATION AND WELFARE ARRANGEMENTS.

The work that is in progress includes, in addition to 700 houses which are in various stages of completion, a welfare department for the men, a large canteen which, when finished, will accommodate two billiard tables, reading, writing and games rooms, and model kitchens capable of serving from 1,200 to 1,400 meals in a quarter of an hour. The cost of building and furnishing the canteen is some £17,000. It has also been necessary to provide sleeping accommodation for some 400 men. In connection with the club premises that are erected for the men, their welfare is considered to a further degree that does infinite credit to the organisers. The welfare department, when completed, will include a resident doctor and a complete Red Cross establishment. Already playing fields have been acquired—these will afterwards form a public recreation ground—and dressing-rooms erected thereon. In connection with the club, evening classes are organised provided that the demand for any particular subject is sufficient. A large number of the ex-Service workers have applied for a class on modern house construction.

About forty miles of light railway have been laid on the site. Other important items are a large factory that is in course of erection for the manufacture of the blocks ; this will enable the work to proceed irrespective of the outside temperature, there are also standard joinery workshops, stores and administrative offices.

An interesting point is the amount of ex-Service and unskilled labour that is being employed in the manufacture of the blocks. Eighty-five per cent. of the workmen are ex-Service men, 90 per cent. of whom are unskilled. All the work, however, is subject to the most severe and thorough supervision by experts.

Enough has been said to indicate the magnitude of the job. The suggestion of war organisation is further emphasised by the presence of a fleet of old Army lorries and motor buses that are used to convey those men, for whom accommodation is not provided on the job, to and from their homes ; moreover, ammunition wagons are used on the site as labourers' carts, and various Army huts have been erected—huts that have seen service as far afield as Mesopotamia.

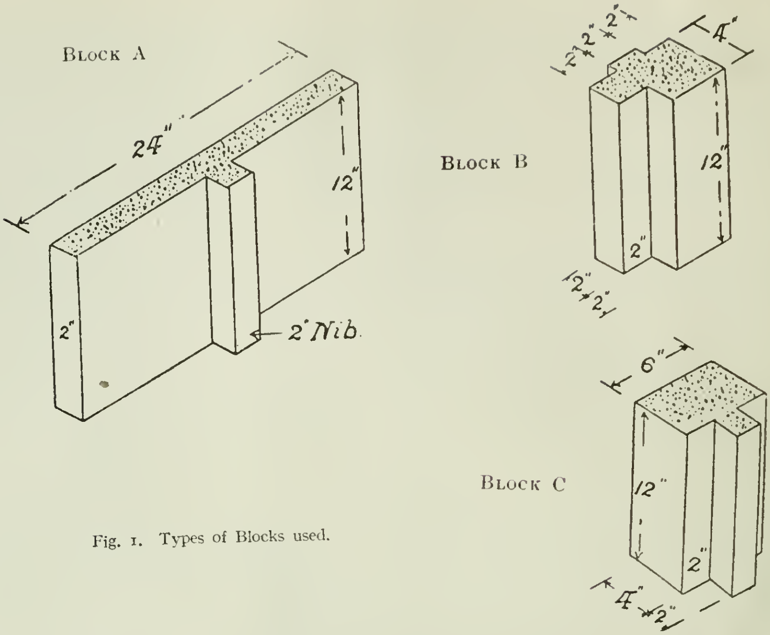
MATERIALS.

There is no doubt that to-day concrete is the ideal material with which to build on such a job, for it means that the organisation can then embrace not only the actual erection of the houses, but the manufacture of the building unit. Owing to the present uncertain delivery of bricks it would be utterly impossible to obtain the same efficiency of output on a job where the men knew that at any moment, if the supply of material ran short, they would be turned off at the end of the week.

CONSTRUCTION.

The system of construction, which is that of the patent of the Economic Building Corporation, is one of hollow concrete walling. The internal and external portions of the wall are formed with a T-shaped block (see *Fig.* 1, Block A). This block has a tongue on the top edge and a corresponding groove on the lower, and a projecting nib. It is all cast in one piece. The nibs bond and the courses are " staggered." Special plate and joist blocks are designed to distribute the load evenly over the wall. There are various standard blocks for different parts of the building. " B " (*Fig.* 1) is a block for windows, doors or other openings, linings, heads, lintels and sills. " C " is for sills, steps, plates, angles, string-courses and foundations.

The aggregate for the outer leaf is gravel, specially selected and graded, while for the inner leaf clinker blocks are used. Originally the blocks for the outer walls were made by the Economic Building Corporation in their own special aluminium moulds on the wet system. This—as we have had occasion to note elsewhere—although an extremely satisfactory method of block manufacture is not particularly expeditious. These moulds were therefore discarded in favour of Winget pressure machines, which have been specially adapted for the manufacture of these blocks. Thirty-two of these pressure machines are now installed on the job (see *Fig.* 2). They are organised in batches which are served by a Winget chain spade concrete mixer. There are twelve of these mixers employed on the job and three crushers, also made by the above firm, of different kinds. An idea of the rapidity with which the work of block making proceeds


Block A

Block B

Block C

Fig. 1. Types of Blocks used.

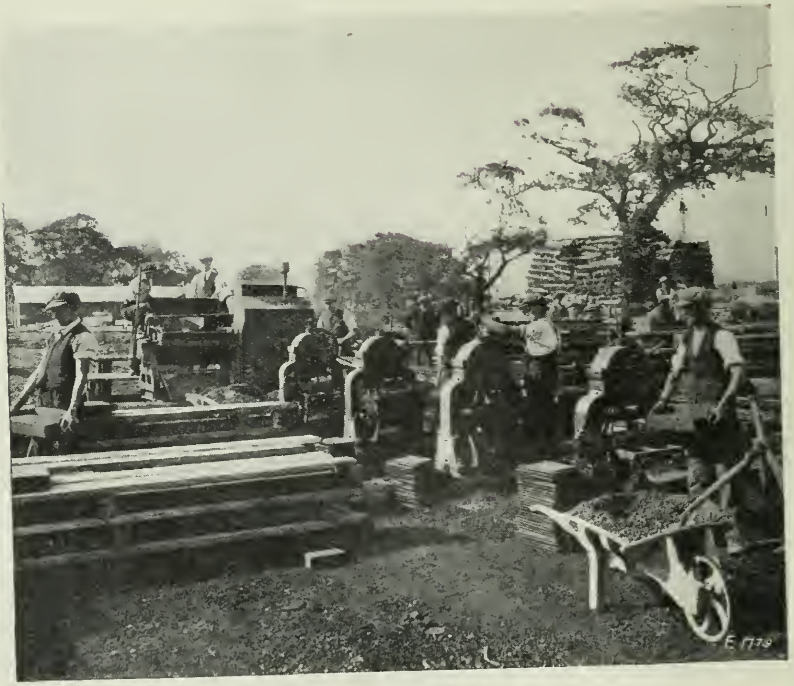


Fig. 2. Some of the Block-making Machines.
Housing Scheme, Liverpool.

may be gathered from the fact that, on an average, slabs of all kinds necessary to complete five houses from start to finish are made each day. Other mechanical appliances on the job include a Winget wagon loader and elevators, both of which save a very considerable amount of labour. *Fig.* 3 shows one of these elevators at work, expeditiously superseding the labourer with his hod.

Fig. 4 shows the special factory, nearing completion, in which it will be possible to manufacture the blocks in all weathers. *Fig.* 5 shows some of the blocks for the outer walls stacked on the ground; *Figs.* 6 and 8 show houses in course of construction and completed.

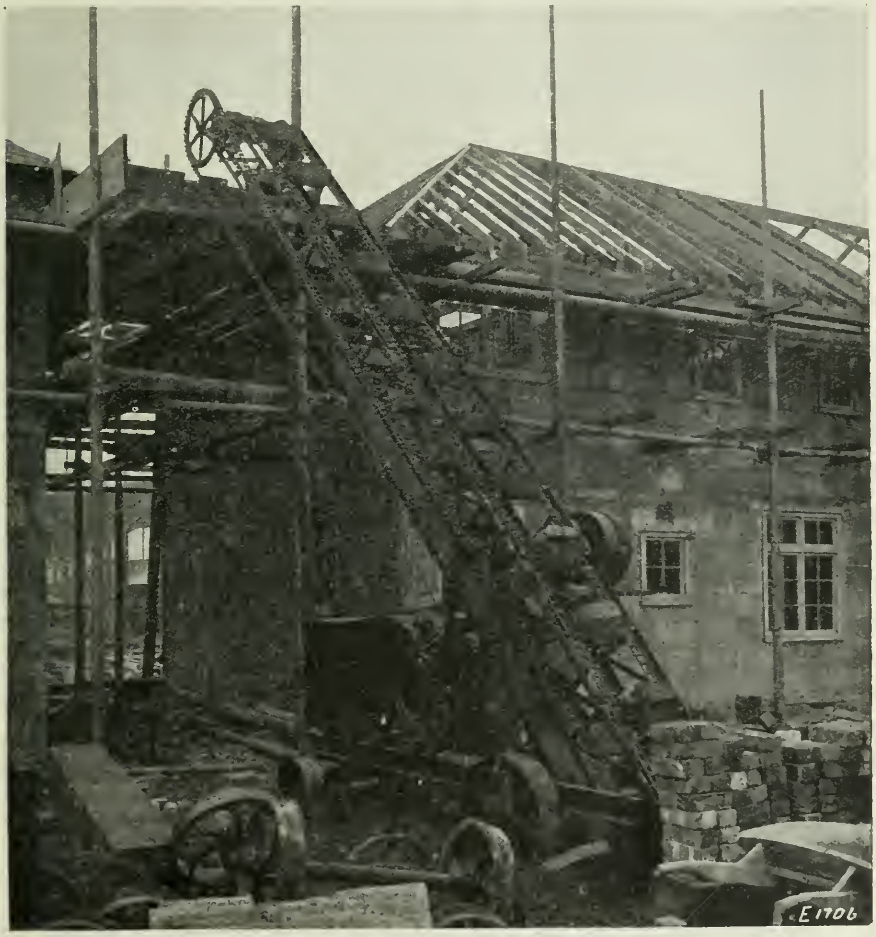


Fig. 3. Showing Elevator in Operation.
Housing Scheme, Liverpool.

The whole housing situation at Liverpool is one of particular interest, for the town has long been known for its pioneer work. The present estimated shortage of houses is 15,000. Towards making good this deficiency some 1,224 acres of land have been acquired, and layout plans have already been prepared for more than half this area and contracts have been let for making the roads

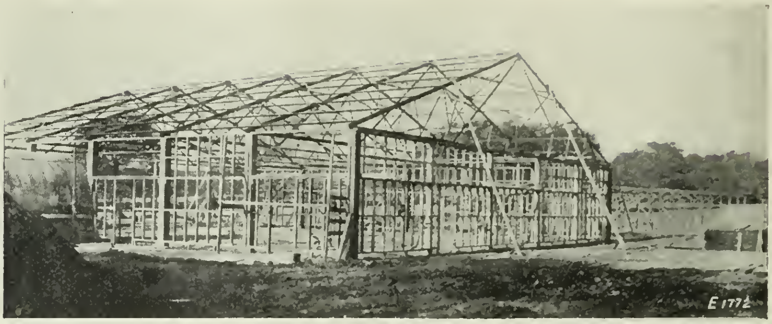


Fig. 4. Block-making Factory.
Housing Scheme, Liverpool.

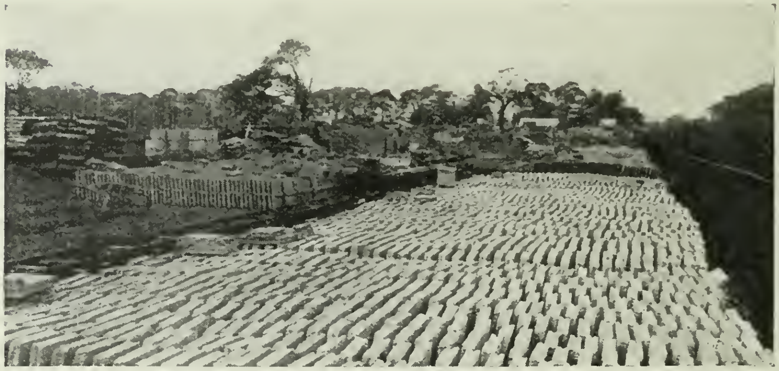


Fig. 5. Stacking Ground.
Housing Scheme, Liverpool.

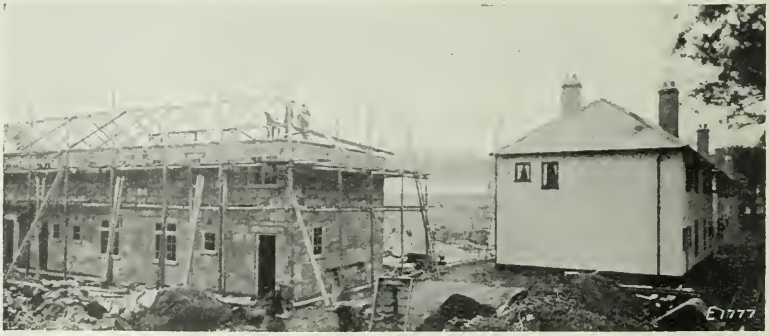


Fig. 6. Houses under Construction, Garston Estate.
Housing Scheme, Liverpool.

and sewers, so that this land is now available for 10,000 to 12,000 houses. Contracts have been let for 6,300 houses, including a direct labour scheme. Two hundred and six houses are tenanted, and in addition there are completed and occupied 484 temporary dwellings. Work is now in progress upon 1,608 houses, making a total of about 2,300.

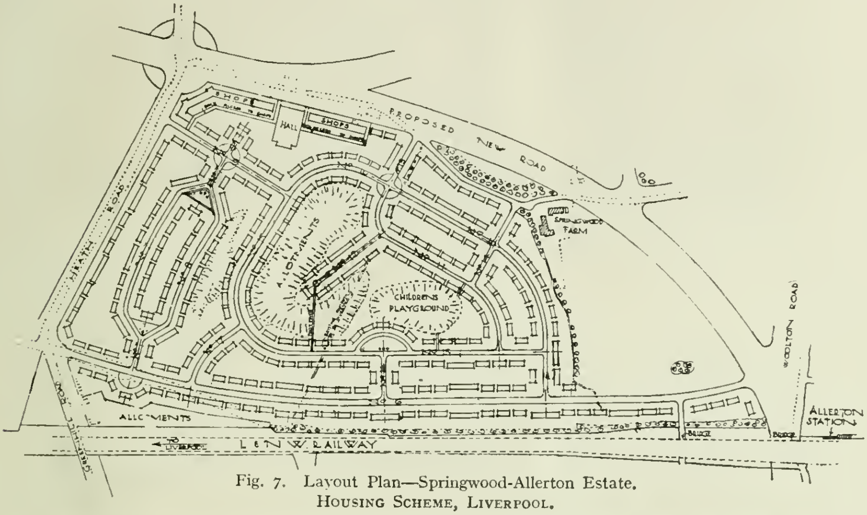


Fig. 7. Layout Plan—Springwood-Allerton Estate.
Housing Scheme, Liverpool.

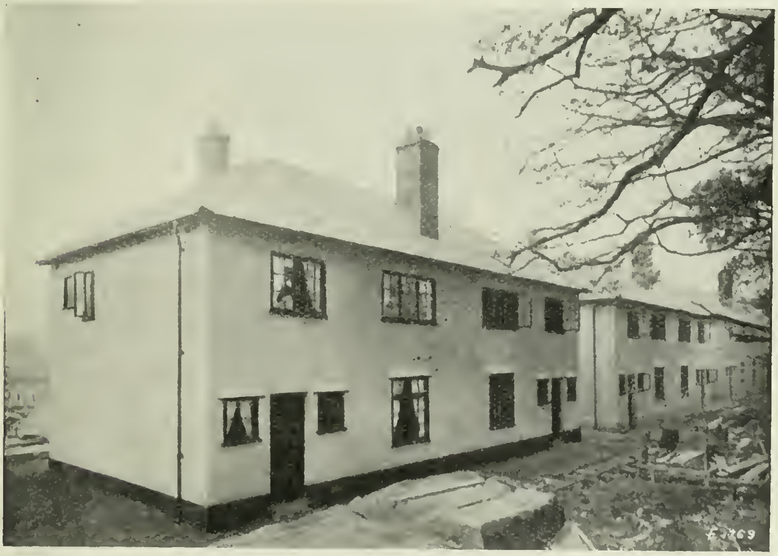
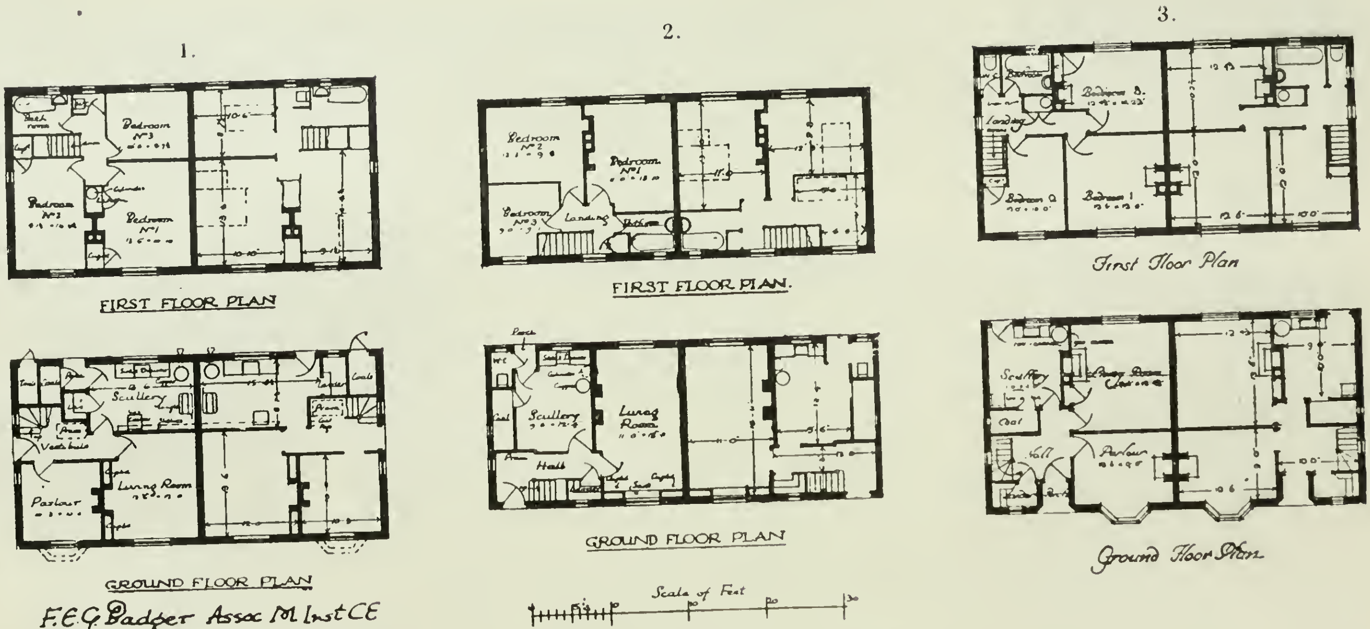


Fig. 8. Finished House, Garston Estate.
Housing Scheme, Liverpool.

On the Garston estate there are five types of house plans in use; these are further varied in appearance by grouping and by the addition of gables and similar features which break the frontage and roof line. They are all parlour type houses. In many housing schemes at present in progress it has been found



F. E. G. Badger Assoc M Inst CE
Director of Housing
Municipal Buildings
Liverpool, September 1920

Fig. 9. Types of House Plans.
Housing Scheme, Liverpool.

difficult, owing to the high cost, to provide many of the small additions that do so much to simplify the daily routine of housework.

At Garston there are to be found many small improvements. For example, a combination dresser is installed in the living-room, which is also fitted with bookshelves and a folding desk. Linen, boxroom and cupboard accommodation has received careful consideration. Gas cookers are installed and electric light.

The houses have all been designed by Mr. F. E. G. Badger, A.M.Inst.C.E., who is the Director of Housing at Liverpool. *Fig.* 7 shows the layout of the Garston Estate, or the Springwood-Allerton Estate, by which name it is also known, and certain types of house plans which are being used on the estate may be seen in *Fig.* 9. It will be noted that a considerable amount of space is devoted to allotments and open spaces.

Finally, an idea of the determination with which the Economic Building Corporation are facing their task may be obtained from the fact that in order that the work may proceed steadily throughout the bad winter weather, in addition to the factory for block making, the men of the outside trades are being supplied with oilskins, and it is proposed to provide fabric coverings for some of the houses in course of erection.

MEMORANDA.

How to Obtain Watertight Concrete.—Where watertight concrete construction is desired, particular attention must be given to the method of proportioning, and the method of mixing and placing of the concrete. Care should be taken to ensure the proper bond between the different batches of concrete or between the work done on different days. This does away with leaky seams or joints. When it is necessary to stop work, the new concrete, when work is resumed, should not be poured before the previously placed concrete has been especially prepared by roughening in some way and painted with a coat made of neat cement and water.—*Concrete, U.S.A.*

Reinforced Concrete Bridge : Regent's Canal.—A piece of work which is of some interest, owing to the conditions under which it has been done, is the construction of a new reinforced concrete bridge over the Regent's Canal, near York Road, King's Cross. This bridge forms part of a scheme to provide a new entrance from Wharf Road to the Great Northern Railway Company's goods yard, which includes the provision of new approaches, and the demolition of the old steel bridge over the canal.

Owing to the necessity of not obstructing the canal, it was found impossible to construct this bridge in place, as the necessary shuttering and supporting timbering would have reduced the headway and waterway width below the permissible limit. It was therefore decided to construct the three girders of the bridge independently and afterwards place them in position. The girders were accordingly built on shore, in line with their proper positions, and when finished each was lifted on to two four-wheeled trucks. When they were ready for launching, one bent of piles was driven in the fairway and a track laid on temporary girders thrown across the canal. The girders were then launched in succession, and on being carried over were jacked and lowered into position after the removal of the temporary gear. The operation was quickly accomplished and the headway was not obstructed at all, while the one pile-bent reduced the obstruction of the waterway to a minimum, both in the matter of actual width and length of time. The centre girder weighed 50 tons. The span is 45 ft. Once the three girders were placed, work was commenced on the flooring in place. For this, shuttering hung from the top side of the girders was employed, so that nothing interfered with the full head room for canal traffic. The work has been carried out by Messrs. Sir Robert McAlpine & Sons, Westminster, S.W., for the Great Northern Railway, under the supervision of the latter company's engineer, Mr. C. J. Brown, C.B.E., M.Inst.C.E.

THE TREATMENT OF SMALL CONCRETE HOUSES.

By H. J. BIRNSTINGL, A.R.I.B.A.

The relationship between the form of a building and the material from which it is built, the extent to which the latter does and should control the former, is a matter that has repeatedly occupied the attention of those who desire to formulate the various and diverse qualities that characterise good architecture. At some time it has been insisted that the intimacy of this relationship should be made one of the most important tests, at others it has been thought that the outward form of a building is all with which it is necessary to be concerned. In addition, however, to the relationship of form to material, that of form to purpose and of construction to ornament should be acknowledged, since they too constitute tests with which it is not possible altogether to dispense in an attempt at architectural assessment.

To observe how these relationships varied in the different great styles of architecture would constitute a research of rare interest. As a superficial generalisation, it might be said that there was this difference in the decadence of certain of them. The decay under the Roman Empire was an abuse of ornament, characterised by its useless and unrelated profusion. The decay of Gothic was an abuse of material; stone used as if it were wood, or even metal. The decay of the Renaissance was an abuse of form; the classic elements deprived of their real use and significance and robbed of their virility by being assigned to tasks unbecoming to their origins.

The last two years have witnessed a determined attempt to alleviate the housing shortage by the use of a material that has hitherto been used almost exclusively—in England—on larger works. At the present time cottages are being built of concrete in almost every part of the country. For the most part, considered purely as contrivances of protection against the elements, the results are satisfactory, but the complex nature of man demands more from a building than that it should perform, in the very crudest way, an absolutely utilitarian function. Consciously, or unconsciously, he requires an æsthetic pleasure; the pleasure that is yielded by colour, form and texture, and it is the failure to supply these that has caused the concrete cottage to be regarded with obloquy. The questions naturally arise: Must concrete cottages be dull? Should they endeavour to follow the traditional lines of cottages built in other materials, or should they evolve a new form which is the outcome of the particular qualities of the material? To the first of these questions it is easy to reply. There are no more inherent reasons why a concrete cottage should be dull, than there are for a brick cottage. Yet a dull brick cottage is unfortunately an all too common phenomenon. The second question, however, is one requiring much consideration.

In the first place the methods of using concrete vary to a greater degree than is to be found with most other building materials, certainly more than is the case with brick or stone. It is only necessary to point to such diversities as concrete block construction, monolithic construction and the gunite house in order to realise that these diversities are, indeed, so great as to make it appear that different materials, rather than the same material differently handled, are being employed. It will thus be apparent that, where the new material most nearly approximates to an existing one, any change in form or treatment will be less marked, than where a new material constitutes a radical departure from the normal. Thus it may be expected that the concrete block house will not depart so completely from the generally accepted forms as the monolithic house.

Where bricks of an inferior quality are used it becomes necessary to apply a protective coating in the form of a rendering or of a rough cast ; the concrete block is similarly used, where the aggregate is sufficiently good to produce a block that will withstand the weather, and that will present a good appearance, both as regards texture and colour, the joints are pointed and a fine and pleasant wall is produced. Where, however, an aggregate is used that will not produce a block of such fine quality, it is necessary to resort to rough casting or similar treatment. *Figs.* 1 and 2 show some concrete block houses at Chepstow designed by Mr. Henry E. Farmer, F.R.I.B.A. It will be seen that in *Fig.* 1 the outsides of the houses are rendered and the treatment is very similar to that of a brick house on which facing bricks are not used. *Fig.* 2 shows a pair of houses nearing completion on which the concrete is not faced. In connection with this illustration two points are worthy of consideration. In many houses the appearance is completely marred by the employment of too large a block. The result cannot be satisfactory where the unit is altogether out of proportion to the size of the building ; the unit must be in scale, otherwise windows, doors and other features lose their relative values. The second point to be noticed is that no attempt has been made to imitate stone work ; it is easy to cast a block on a pallet so that a vermiculated hammer-dressed, or other similar face is produced. Nothing is more contrary to the canons of good taste than that one material should endeavour to insinuate itself in the guise of another. The surface of the block will depend chiefly upon the aggregate that is obtainable. At Chepstow local stone chippings were largely used ; this, as might be expected, will produce a more pleasant facing block than would result in districts where destructor clinker was the only available aggregate. *Fig.* 3 shows a bungalow built on a patent system of construction which divides the wall surface into bays by means of projecting piers. The surface of this bungalow is rough casted, and the projection of the piers is here a distinct advantage to the design, because these vertical lines are emphasised by the proportions of the windows. It is just upon such small matters that success depends. It is but necessary to substitute, for a moment in imagination, long low casement windows and the charm, the " rightness " of the design disappears. It is true this is but a matter of architectural composition, but with the concrete cottage it is unfortunately one that so often receives insufficient consideration. It would seem, then, that the concrete block house makes no particular demand upon the designer. The usual limitations will apply, such as local resources, the sum to be expended, accommodation to be provided, and it is these factors, rather than any new and startling qualities of the material, or method of using it, that will govern the design.

From the concrete block we pass on to the consideration of other methods that proceed farther into the unknown. For the most part steel is not required in cottages, the loads to be dealt with being small. Steel-framed, concrete-covered houses have, however, been erected in various parts of the country, but their success, considered financially, depends almost entirely upon standardisation of the parts. A standardised steel frame leaves very little scope for diversity in design. If the design be good, it may well be worth repeating, but good architecture cannot flourish under such limitations. There is no advantage in constructing cottages by means of a steel frame unless they can be built more cheaply than other materials, and it will only be possible to build them more cheaply if the component sections are standardised. The only freedom left to the designer, therefore, is in the matter of fenestration, details of cornices, eaves, door hoods,

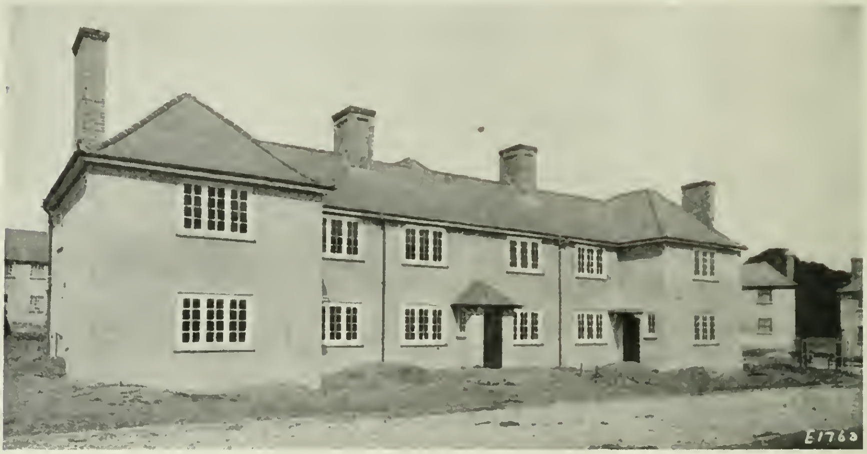


Fig. 1. Houses at Bulwark, Chepstow.
[*Architect: Henry E. Farmer, F.R.I.B.A.*

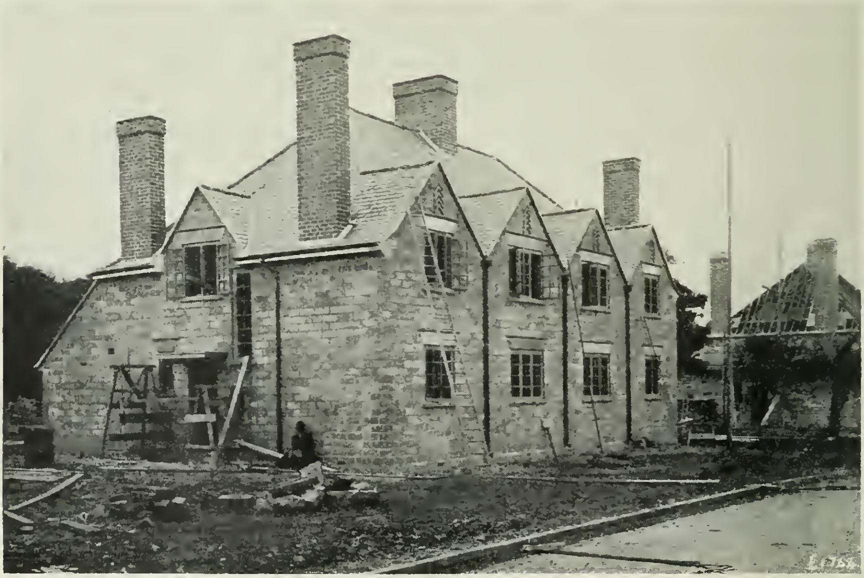


Fig. 2. Houses at Bulwark, Chepstow.
[*Architect: Henry E. Farmer, F.R.I.B.A.*

surface treatment, and it is inevitable that most architects would, quite rightly, chafe under such restrictions. That, however, the steel frame house is capable of yielding delightful results is shown in *Fig.* 4, which is a house at Dormanstown designed by Messrs. Adshead & Ramsey and Prof. Patrick Abercrombie, but its success depends upon a fine knowledge of architectural design. The limitations imposed by the steel structure have been turned to the very best account. The same skeleton framework in the hands of a less experienced person, and one who had not studied and assimilated the traditions of English architecture, would have

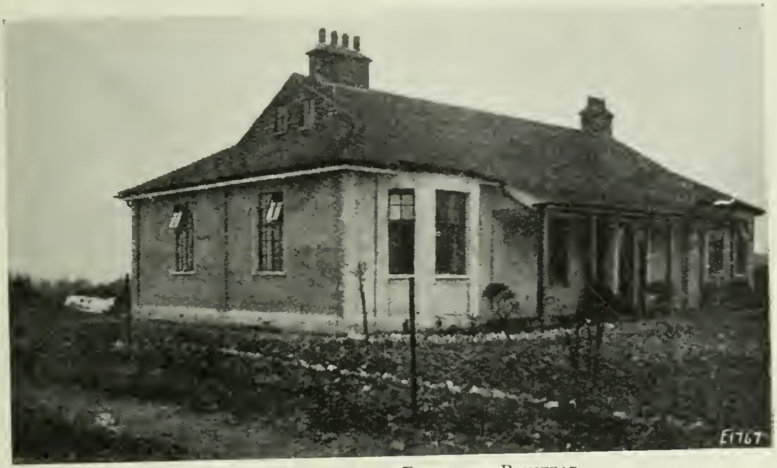


FIG. 3. A SIX-ROOMED BUNGALOW, BANSTEAD.
[*Architect: H. D. Seales Wood, F.R.I.B.A.*

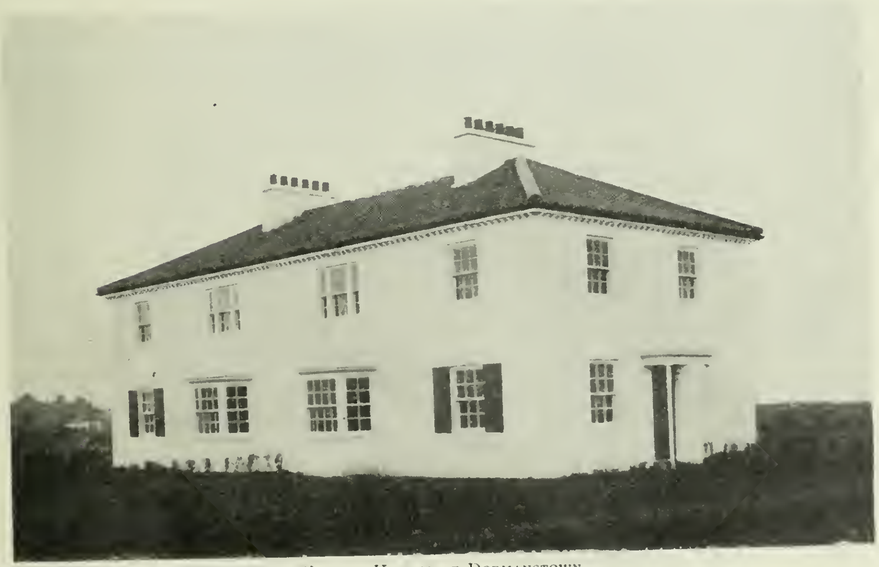


FIG. 4. HOUSES AT DORMANSTOWN.
Architects: Messrs. Adshead, Ramsey, and Prof. Patrick Abercrombie.

resulted in a building of the utmost dullness, bereft of all charm and character.

We are now led to the consideration of another aspect of our subject: the suitability of a particular architectural composition to its surroundings, both natural and architectural. There is no doubt that in rural districts and in small towns—in contradistinction to large cities—a certain harmony is to be noted between buildings and their natural surroundings, since local materials were so largely used. In stone districts, the local stone emphasises the prevailing tone in the landscape. The shape of a building, too, will often, in some quite subtle way, bear a relation to the character of the country, crouching into the ground, as it were seeking protection, or aspiring upwards, and seeming to reiterate the prevailing lines of trees or cliffs. Such things as these cannot be neglected even when designing in concrete. Thus it should at once be appreciated that a house, such as is illustrated in *Fig.* 4, has a suitability that is limited by environment and position. Lack of consideration of this matter might lead to condemnation of the design by the layman or by a hostile critic of concrete construction, although the fault does not lie intrinsically with the design. And this aspect of the problem assumes even greater prominence in considering monolithic construction, which lends itself to quite unusual forms which may offend in certain juxtapositions yet please in others.

(*To be concluded.*)

Building for the Hide and Leather Realty Co., Manhattan.
(*See page* 21.)

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

THE American Concrete Institute will be holding its Annual Convention in Chicago on February 14, 15 and 16, 1921.

Their President has extended a cordial invitation to such of our members as may happen to be in America at the time.

In extending this invitation he adds that doubtless the two Institutes will find mutual advantage in the discussion of problems equally affecting both Institutes.

It is hoped that our members will shew their appreciation of this act of hospitality by taking advantage of the President's kindness.

THE ANNUAL DINNER.

The Annual Dinner of the Concrete Institute was held in the Venetian Suite, Holborn Restaurant, London, on Thursday, December 9, 1920. The President, Mr. E. Fiander Etchells, A.M.Inst.C.E., A.M.I.Mech.E., Hon. A.R.I.B.A., etc., was in the Chair. Amongst those present were :—Mr. J. W. Simpson, Member Corr. de l'Institut de France, President of the Royal Institute of British Architects ; Mr. W. B. Worthington, B.Sc. (Vict.), Vice-President of the Institution of Civil Engineers ; Rev. S. A. Alexander, M.A., Canon of St. Paul's Cathedral ; Mr. G. Topham Forrest, F.G.S., F.R.I.B.A., Hon. M.C.I., Architect to the London County Council ; Captain H. Riall Sankey, C.B., R.E. (ret.), M.Inst.C.E., President of the Institution of Mechanical Engineers ; Sir Charles T. Ruthen, O.B.E., F.R.I.B.A., M.C.I., President of the Society of Architects ; Major J. Wightman Douglas, D.S.O., R.E., Commissioner for Special Construction, Ministry of Health ; Mr. C. Le Maistre, A.M.Inst.C.E., M.I.E.E., Secretary of the British Engineering Standards Association ; Mr. T. J. Gueritte, B.Sc., Ing. E.C.P., President-Elect of the Société des Ingénieurs Civils de France ; Mr. Norman Scorgie, M.Inst.C.E., Vice-President of the Institution of Municipal and County Engineers ; Mr. Arthur Crow, F.R.I.B.A., President of the District Surveyors' Association ; Mr. Bernard Dicksee, F.R.I.B.A. ; Mr. G. Springfield, F.J.I., President of the Institute of Journalists ; the following Vice-Chairmen :—Sir Henry Tanner, C.B., I.S.O., F.R.I.B.A., Past-Pres. C.I. ; Mr. F. E. Wentworth-Sheilds, O.B.E., M.Inst. C.E., Past-Pres. C.I. ; Mr. H. D. Searles-Wood, F.R.I.B.A., F.R.San. I., Past-Pres. C.I. ; Dr. J. S. Owens, F.R.G.S., F.G.S., A.M.Inst.C.E., Vice-Pres. C.I. ; Mr. C. H. Colson, O.B.E., M.Inst.C.E., Past Member of Council C.I. ; and Captain P. L. Marks, M.J.I., Licentiate R.I.B.A., Sec. C.I. ; and a numerous company of members, including Major J. Ernest Franck, F.R.I.B.A., Vice-Pres. C.I. ; Sir Alexander Gibb, K.B.E., C.B., and other guests.

In proposing the first toast, the President said: "I have the honour to propose the health of the King, The King of the British Empire, the King of the British Commonwealth of Nations."

In proposing the second toast, the President said: "Gentlemen, I have the honour to propose the toast of the Queen and the Royal Family, including the Prince of Wales, that bright young man, who is the reinforcement of our concrete empire." (Cheers.)

Sir Charles Ruthen, O.B.E., in proposing the toast of H.M. Forces, said: "We have been so used always to a wonderful Navy, that we sometimes forget that these silent monsters are floating round, guarding this dear old island of ours. With regard to the Army, it is almost impossible to speak. At one time the British Empire had a tiny army, but the great citizen army, which was created during the War, was the greatest army which the world has ever known."

LIEUT.-COL. H. S. ROGERS, C.M.G., D.S.O., M.C.I., on rising to respond, said: "The proposer of the toast has dealt with the Navy. Unfortunately I did not know much about what the Navy was doing at the time, but I know now what it did. I know that we should not be here to-night were it not for the Navy. I myself spent most of the four years or more in the battle zones in France. I dare say that some remarks with regard to what I came across, relating to concrete, may be of some interest to members. Undoubtedly the Boche used a great deal more concrete than we did; he was in a concrete country and could impress his labour. I recall one reinforced concrete bridge, which I had to repair, west of Cambrai; it was a two-span bridge, carrying the main Cambrai-Solesmes road over two double lines of rail just north of the Cambrai annexe railway station. The rail was in a deep cutting with about 20 ft. from rail level to road level. The road on the bridge was paved with heavy setts with a narrow overhanging footway on either side. The roadway was carried on a reinforced concrete deck. At the time we took Cambrai, I was in charge of the bridges, the water supplies and the roads behind the actual fighting divisions; the divisions fought in front, and we got shelled behind (laughter), because all our work was actually where the Boche had blown up things, and we had to make them good. On the morning of October 9th, 1918, we took Cambrai." (Applause.)

MR. J. W. SIMPSON, P.R.I.B.A., in proposing the toast of the Concrete Institute said: "I am honoured by being invited here to-night and in having the privilege of proposing this toast of the Concrete Institute. 'Con cresco'—'I grow together,' 'Concretus'—'United in growth'; I think the name is a most singularly happy one. Those of you who are not members of this Institute will learn with some surprise, I think, that it is only twelve years of age, with a present membership of 1,111. The Institute over which I have the honour to preside was founded in 1834, that is, eighty-six years ago. If the Concrete Institute continues to multiply in the same ratio as it has in the twelve years of its existence, I can see that by the time it has run its eighty-six years it will embrace the whole population of the British Isles. (Laughter.) The history of the Institute, though short, is very striking. It was at once recognised as worthy of standing beside the Institution of Civil Engineers, the Royal Institute of British Architects and the Surveyors' Institution. We of the Royal Institute are rather proud of the position which has been achieved by our members in connection with your body, such as your present President (who is an

Hon. Associate of the Royal Institute), Mr. Searles-Wood, one of your Past-Presidents, and an old friend and colleague of mine on the Council of my Institute, Sir Henry Tanner, another of your Past-Presidents, Mr. William Dunn, Major Ernest Franck, one of your Vice-Presidents, and many others.

I cannot give this toast without some reference to the work of your President. He has accomplished an immense work. A great deal of it, as you know, is anonymous, and I must respect his modesty with regard to that, but there is one work which he has done, and of which all of us know and speak, that is his work in connection with the Report of this Institute on the Standard Mathematical Notation for Engineering Formulæ. (Applause.) Its common sense and its practical utility have led to its acceptance to the exclusion of all other proposals. It is accepted and adopted in all Government publications and official documents. It is one of the great educational works of modern times. It has saved time and energy in calculation, and it has cleared the pathway of the student. Such a work has not only enhanced your President's own already brilliant reputation but it is an honour and a glory to this Institute. (Applause.) I congratulate him and the Concrete Institute on that very great performance. Gentlemen, I ask you to drink with full glasses to the success and prosperity of the Concrete Institute." (Loud applause.)

The toast was drunk with much enthusiasm, the guests rising and singing "For he's a jolly good fellow."

The President, on rising to reply, was received with prolonged cheering.

He said :—" Gentlemen, I thank you very sincerely for the manner in which you have received this toast. I am prepared to discuss steel work, reinforced concrete and special methods of construction, but as you know, I resolutely decline to be drawn into any discussion on politics or policy. Therefore I shall take great care to restrict my remarks to events in some other country or some other continent, or some other century or epoch. (Applause and laughter.) For example, I absolutely decline to say a word about the present shortage of houses or the dearness of clothing. (Laughter.) Instead of that I will tell you about the shortage of houses in Lagado about 234 years ago. (Renewed laughter.) I quote from Dean Swift's account : ' In the year 1686, or thereabouts, certain persons went up to Laputa, either upon business or diversion, and after five months' continuance came back with a very little smattering in mathematics, but full of volatile spirits acquired in that airy region. These persons, upon their return, began to dislike the management of everything below, and fell into schemes of putting all arts, sciences, and mechanics upon a new footing. To this end they procured a Royal Patent for erecting an academy in Lagado, and the humour prevailed so strongly among the people that there is not a town of any consequence in the kingdom without such an academy. In these colleges the professors contrived new rules and methods of building and new instruments and tools for all trades and manufactures whereby they undertake one man shall do the work of ten, a palace may be built in a week, of material so durable as to last for ever.' (Laughter.) That sounds like concrete, but it is what Dean Swift says, and he goes on, 'The only inconvenience is that none of these projects are yet brought to perfection, and in the meantime the whole country lies miserably waste, the houses are in ruins, and the people are without food or clothes.'

There is another matter I should like to bring to your notice. The Ministry of Health Housing Department recently published a Standard Specification for Cottages. I refer to document SOP—547/D82/7916. This is an excellent document in its way, but it contains no penalty clause, and having regard to the present tendency to use methods of construction having an uncertain standard of stability, and having regard to the tendency to reduce the standard of stability to the narrowest limits, I would suggest that the Ministry fall back upon precedent and incorporate some special clauses from the Code of Hammurabi, who was King of Babylon about 2,000 years B.C. He promulgated the first Building Act of which we have any definite knowledge, and he is supposed to have given a few hints to Moses himself. (Laughter.) The Code of Hammurabi states that ' If a builder has built a house for a man and his work is not strong, and if the house he has built falls in and kills the householder that builder shall be *slain*. If the child of the householder be killed the child of that builder shall be slain. If the slave of the householder be killed he shall give slave for slave to the householder. If goods have been destroyed he shall replace all that have been destroyed, and because the house that he built was not made strong and it has fallen in, he shall restore the fallen house *out of his own personal property*. If a builder has built a house for a man, and his work is not done properly, and a wall shifts, then that builder shall make that wall good *with his own money*.' Those clauses tend to safer building. Gentlemen, time presses, therefore I will say no more, but I thank you for the way in which you have received the toast of the Concrete Institute, and for the kind references you have made to myself." (Applause.)

MR. F. E. WENTWORTH-SHEILDS, O.B.E., PAST-PRESIDENT C.I., proposed the toast of the Visitors. He said : " We are exceedingly pleased and proud to-night to see so many honourable guests facing us, so many Presidents of the various organisations bearing honourable names. The War has taught us many things, and among others it has taught us the value of *co-operation*. Our Societies exist for *co-operation* of brains. I hope with confidence that in the future a great deal more of that co-operative work will be done between the various Societies who are represented at these tables. Among our distinguished guests are representatives of the various kinds of professions and of all schools of thought. It would be invidious to mention any of them in particular, but I have been asked to couple this toast with the name of one who, although not a builder, takes a very keen interest in building. Canon Alexander has a very soft spot in his heart for architects, because he takes such an immense interest in that very fine work, the restoration of St. Paul's Cathedral." (Applause.)

CANON ALEXANDER said :—" I have always felt very great sympathy with the case of Mr. Joseph Chamberlain, who was to make a great public speech on political subjects at a Midland dinner, when he was in the height of his fame, and the Chairman, at the proper time looking round upon his guests, turned to him and said, ' Mr. Chamberlain, shall we have your speech now, or shall we let them enjoy themselves a little longer ? ' (Laughter.) I feel sure that you have kindly invited me here to-night because of the very serious piece of work now being carried out upon the fabric of St. Paul's Cathedral. We have been occupied for the last eight years in trying to keep the Dome standing, and the end of that work is not yet in sight. I am afraid that we may take some twenty years to finish it, though we might perhaps do it in half the time if the funds at our disposal were larger. In the eight years that have passed, I have made one very strange discovery, and that is, that engineers and architects do not always take exactly the same view. (Laughter.) But though we have had a little ripple of difference on the surface, it has never interfered with the actual work, and we have gone forward and completed, I think I may say, the most vital portion of the unique piece of work executed upon that great building since it was first erected. There is an idea abroad at the moment that some Government office might possibly come into control, or partial control, of our cathedrals and our great parish churches. I venture to think, and I speak with the experience of one who has been Canon of two cathedrals for nearly twenty years, that there is no real necessity for that assistance. (Hear, hear.) Whatever may have been the case in the last century, it is certain that the Cathedral Chapters everywhere and the directors of our great parish churches are thoroughly alive to their responsibilities as custodians and guardians of the fabrics with which they are connected ; and moreover we are taking steps just now to open in every diocese in the land, committees who may see that the necessary work is carried out. I thank you very much on behalf of myself and the other visitors for the kind way in which you have received this toast." (Applause.)

The proceedings then terminated.

SPECIAL APPLICATION OF REINFORCED CONCRETE IN DOCKS.

WITH SPECIAL REFERENCE TO THE REINFORCED CONCRETE GATES AT TILBURY DOCKS.

By H. J. DEANE, B.E., M.Inst.C.E.

The following is an abstract from a Paper read at the Ninety-Eighth Ordinary General Meeting of the Concrete Institute on December 16th, 1920. The paper was illustrated by lantern slides and was followed by discussion.—Ed.

The application of reinforced concrete to dock works necessarily includes many uses which are common also in other commercial spheres, for instance, sheds, warehouses, offices, railways, roads, jetties, bridges, etc. As such it is not proposed to include them in the subject matter of this paper except where any special considerations give them characteristics which have essentially to do with docks and which are only, or principally, associated therewith.

Dock and River Quay Walls.—Among the worst conditions with which the engineer is frequently faced are those in which the geological formation consists of unstable strata such as are found in many of the estuaries in Great Britain and elsewhere. In the Thames valley, for instance, the conditions are far less favourable than those where solid rock or chalk foundations can be obtained without much difficulty and at no great depth, and where the superimposed strata are of a much firmer character.

The strata immediately underlying the northern bank below London Bridge consist mainly of alluvium and river drift which have been deposited in the course of ages by the river itself.

The alluvium, however, in which the Victoria and Albert and Tilbury Docks system are for the most part constructed is of a nature (particularly in the latter case) where difficulties are constantly being met, and although the original dock walls at Tilbury were constructed in open trench, yet when the Tilbury Main Dock Extension was first commenced the alluvium (or what is locally known as "bungum") had become so soft, probably owing to its being saturated with water from the docks, that it was found impossible to proceed in open trench and the walls had to be carried down to gravel by sinking a series of monoliths side by side on the line of the quay walls. These monoliths were built up of pre-cast concrete blocks, each layer breaking joint with the one below, and were designed so that four pockets or wells were left from which the material at the bottom could be grabbed out. As the material was removed so the monolith sank and more layers were built up. There was no reinforcement in the blocks, which weighed up to 5 tons each, the size of the monoliths being approximately 30 ft. by 30 ft.

At Valparaiso reinforced concrete monoliths were used in forming the Customs Quay Wall, and somewhat similar monoliths were used at Copenhagen and sunk in position as caissons.

A number of examples are to be found where L-shaped walls have been adopted for river and quay work with the necessary stiffening brackets or gussets to support the vertical portion against both external and internal pressure.

A notable example of an L-shaped wall is to be found in Sydney Harbour, where pre-cast trestles were sunk into position on a prepared rubble bed and the space behind filled up and reclaimed. The total length of wall was about 1,350 ft. and it served as a retaining wall and quay wall combined, the total height of each trestle being 21 ft. 6 in. with a 15 ft. horizontal leg and having a width of 3 ft. 6 in.

Reference might here be made to the quays immediately behind the quay walls at Tilbury Docks. The original designs did not take into account the extraordinary nature of the ground, as no experience had been obtained of its want of stability. The quays were simply surfaced with ordinary concrete. The heavy traffic and the yielding ground underneath have, however, produced a state of things which now and then necessitates pulling up the old concrete, filling up the spaces due to settlement, and then re-concreting; but the underlying material never becomes properly solidified, and for any further extensions the question of constructing such quays in reinforced concrete with suitable supports will have to receive careful thought. Indeed the whole design from the quay edge right back to the sheds may have to be radically altered.

Lock Entrances and Graving Docks.—These two facilities form essential features of most dock undertakings, the provision of lock entrances being determined by the consideration as to whether the range of tide is large enough to necessitate the conservation of the water in the docks. There would appear to be very considerable scope here for adopting reinforced concrete caissons which could be erected *in situ* and subsequently sunk to the correct level, or possibly by dredging out a wide trench the caissons could be floated into position and sunk, the slope behind being subsequently filled in.

Floating Dry Docks.—These have many advantages over the ordinary graving dock, more particularly where local circumstances make the construction of the latter difficult and costly. Such docks are generally built of steel or iron. It is obvious in any case that the maintenance of such structures adds enormously to the cost of working, and the advantages from the use of reinforced concrete have been recognised and one (if not more) of such docks has been constructed and is now in use.

Slipways.—Whilst on the subject of ship repairs reference should be made to the use of slipways. Timber, steel and iron have been used extensively for the ways, but owing to the heavy loads imposed and the rapid deterioration of such materials between wind and water reinforced concrete has been successfully used.

In America launching (or slip) ways 990 feet long built in reinforced concrete were erected in connection with the construction of some new warships about three years ago, and in the same country a group of ten ways 270 feet long were constructed for the repair of river patrol vessels on the Missouri.

Lighthouses and Beacons.—Numerous examples of the successful use of reinforced concrete in lighthouse works can be found, and little comment is necessary. The main point to be borne in mind, however, as in all work exposed to attrition and the action of salt water, is sound impervious concrete with ample covering to the steel reinforcement.

Groynes and Sea Defences.—Reinforced concrete has been extensively used in such works, more especially in Holland, where some very ingenious inter-locking devices have been adopted for the purpose of preventing erosion to the banks of dykes and river walls.

The design overcomes the disadvantages connected with continuous structures by providing pre-cast flat slabs 18 in. square by 2½ in. thick and placing them chess-board fashion, the white squares having lips or projections under the black square, which in turn are kept down in place by concrete pegs.

Pontoons and Dummies.—Without encroaching on the subject of reinforced concrete ships and barges reference must be made to the employment of this material for pontoons and dummies.

Many instances of the former were to be found in the docks on the Thames and a considerable number of such pontoons were in use at one time. These were generally built of steel or iron, but in due course they became worn out and obsolete and at one time it was proposed to replace them with reinforced concrete pontoons. The designs provided ample strength against crushing, and the heavy timber fendering formed an important feature, but owing to the gradual abandonment of the use of such craft no further steps have been taken in this direction.

The dummies employed in the floating landing stages in connection with steamboat piers and in the larger types such as those at Liverpool and Birkenhead offer splendid opportunities for construction in reinforced concrete. The consideration of dead weight does not materially affect the question and, as they can be very fully protected by suitable fendering or belting, damage by collision is a remote contingency.

Crane Tracks and Underground Conduits.—The large growth in the size of ships and the increase in the weight of loads to be handled, whether on the quay side or for repairs purposes in dry dock, have produced a corresponding increase in the dimensions and lifting capacity of cranes and other hoisting appliances. In the early days when hydraulic cranes were first introduced their capacity rarely exceeded 2 tons or their total weight 20 tons. To-day ordinary quay-side cranes have a lifting capacity of from 3 to 5 tons and for the dry dock side may be anything from 15 to 20 tons upwards. The wheel loads are consequently very great and special construction has to be provided for their support. Considerable lengths of such tracks have recently been laid by the Port of London Authority. They are supported on pre-cast piles driven down till a good foundation is secured. These are spanned longitudinally by pre-cast girders supporting the crane rails with pre-cast ties to prevent the tracks from spreading. The ties are generally placed below the bottom of the longitudinal girders so as to allow of the construction of concrete conduits for the trolley wires or feeders which supply current to the electric motors. The conduits are strengthened at intervals with pre-cast reinforced concrete yokes somewhat similar to the cast-iron yokes used in tramway construction. Very little trouble has been experienced from narrowing of the slots and, generally speaking, the arrangement has proved very satisfactory.

A number of 7 ft. gauge cranes are also provided in the vicinity of the Authority's dry docks and these are nearly all laid on pre-cast sleepers, designed by the author; the great drawback to them, however, during construction, is their weight and the liability to damage in transit.

Before passing to the last subject of this paper the author would like to refer in some detail to an unusual application of the use of reinforced concrete in connection with the old lock entrance at the Victoria Docks on the Thames. These docks and the lock entrance were built as long ago as 1855 and were designed on as economical a scale as possible, although considerable foresight was exercised in providing a lock of such large dimensions as 80 ft. between copings and 28 ft. of water below Trinity High Water mark. The gates, which are of iron, are constructed with a double skin and the whole of the 95 tons dead weight is carried on the pintles and rollers when the buoyancy chambers are flooded. The rollers are supported on cast-iron segments secured to the bottom of the lock. The constant use of the gates combined with the inability of the cast-iron segments to withstand the heavy concentrated pressures resulted in the seating under the segments becoming damaged to such an extent that some radical method of reconstruction of the roller paths has become abolutely necessary. It was hoped that by the time this paper was written the reconstruction would have been completed, but circumstances have prevented this, and the effectiveness of the design has not, therefore, yet been put to practical test. The reconstruction referred to is to be carried out by removing the old paths and bearers and forming a chase (to be cut out by diver) capable of taking a pre-cast curved girder having a radius of about 39 ft. and a cross section of 36 in. by 22½ in. and provided with a suitable recess for the reception of the cast steel roller path segments. Steel bolts are cast in position for securing the segments in correct alignment and eyes or lugs are provided for lifting the girder from the quay side and depositing it in its correct position in the lock bottom. The levelling up will be effected in the usual way and the spaces between the old lock structure and the girder will be filled in with cement grout. The girders are designed for the worst conditions during lowering and fixing, and special arrangements are to be made so that when suspended all the slings will take their fair share of the weight.

Reinforced Concrete Lock Gates at Tilbury Docks.—The exigencies of the war necessitated the introduction of reinforced concrete in the construction of ships, barges and other vessels, owing to shortage of the more usual materials such as steel, iron and wood.

The building of a certain number of such barges on Admiralty behalf was undertaken by the firm of Christiani and Nielsen and a suitable site was let to them for this purpose by the Port of London Authority at their docks at Tilbury, Essex. The great advantage of this site was the ready access to the river, and the low marsh level on which the barges could be built obviated the formation of expensive slipways or dry docks. All that was necessary to enable the barges to be floated out into the Tilbury Dock was a cut or passage of sufficient width and depth through the pitched bank.

The closing of this passage against the waters of the dock was the subject of careful consideration, and the contractors eventually decided, with the permission of the Port Authority, to build the necessary lock gates of reinforced concrete.

The entrance passage or channel from the Dock Extension is 40 feet wide in the clear.

The level of the top of the sill at the entrance is 3·13 ft. above Ordnance Datum. The level of water in Tilbury Docks at Spring tides is approximately Trinity High Water or 12·5 ft. above Ordnance Datum, so that at this level there is a depth of water of 9·37 ft. in the entrance to the barge dock. The level of top of coping is 17 ft. above Ordnance, the distance from coping to sill being 13·87 ft.

The sill is segmental in plan, the radius being 26 ft. 4¾ in.

The curved outer faces of the gates are flush with the outer face of the sill and the leaves of the gates are 13 ft. 8 in. deep from top to bottom, there being a space of 2 in. between the bottom of the gates and the top of the sill.

Each leaf consists of a slab 3½ in. thick with double horizontal and vertical reinforcement of ⅜ in. rods spaced 6 in. apart, and is stiffened by four horizontal ribs for the whole length, and one vertical rib at the centre of the leaf is introduced between the horizontals.

The top horizontal rib is widened out to 2 ft. to form a gangway over the lock and has a treble system of reinforcement of ⅛ in. rods with ¼ in. stirrups at 4 in. centres. In thickness it tapers from 5½ in. to 3½ in. and is haunched at the connection with the slab. The two horizontal ribs are 12 in. by 5 in. doubly reinforced with ½ in. rods and ¼ in. stirrups, 6 in. pitch. The bottom rib is 12 in. wide and tapers from 6½ in. to 5 in. in width. The vertical centre rib is 10 in. by 5 in. with double reinforcement of ½ in. rods, ¼ in. stirrups, 6 in. pitch.

Heel Post.—The heel post is 12 in. by 12 in. exclusive of haunches and is reinforced with four ¾ in. rods and four 1 in. rods from top to bottom.

The horizontal lacings are generally ⅜ in. diameter at 6 in. pitch, but at the top and bottom they are placed 4 in. centres and additional ¼ in. rods are introduced.

The reinforcing bars of the horizontal ribs and the slab are carried into the heel post, the ends being hooked round the verticals.

On the top and bottom there are ¾ in. steel plates, 12 in. square, and the vertical 1 in. rods are screwed into these.

The centre line of the heel post coincides with the centre line of the $3\frac{1}{2}$ in. slab.

Bottom Pintle.—An additional $\frac{3}{4}$ in. metal plate is fixed on the bottom by four $\frac{3}{4}$ in. countersunk screws and there is an elongated hole $4\frac{1}{8}$ in. by $5\frac{1}{2}$ in. in each plate to allow of the heel post tightening in the hollow quoin under pressure of the water.

The bottom pivot consists of a steel pin 4 in. diameter held in position by a built-up girder of two channels with top and bottom flange plates and built into the concrete.

Top Pintle.—The top pintle is a 4 in. diameter steel rod fitted into a gaspipe ferrule in the concrete. The anchorage consists of a 9 in. channel secured to the concrete by holding-down bolts with anchor rods. There is an elongated hole $5\frac{1}{4}$ in. long in the channel to allow of adjustment. The anchor strap passes round the top of the pintle and through a cast-iron lug fixed to the channel, and can be adjusted by a nut in the shore end, sufficient play being allowed for the automatic tightening of the gates when subjected to the pressure of water.

Quoins.—Water-tightness is secured by a timber quoin fixed to the concrete post. This is 12 in. wide and the face is curved to a radius of 12 in. The hollow quoin is not curved in the usual manner, but is tangential to the timber face. The timber is fixed to the concrete by $\frac{7}{8}$ in. diameter screws fitting into tapped sockets built into the gate about 12 in. pitch reeled.

Mitre Posts.—The mitre posts are 12 in. by 5 in. haunched to the slab and reinforced with six vertical rods $\frac{1}{2}$ in. diameter with horizontal stirrups $\frac{1}{4}$ in. diameter, spaced 6 in. pitch.

The meeting timbers are out of 10 in. by 4 in. fastened to the reinforced concrete by $\frac{7}{8}$ in. screws in tapped socket similarly to the heel post. The timber projects beyond the outer edge of the meeting post and is bolted to a 5 in. by $3\frac{1}{2}$ in. vertical timber attached in the concrete. The width of the meeting face is 6 in. and the centre line coincides with the centre of the $3\frac{1}{2}$ in. slab of the gate.

There is no clapping sill in the ordinary sense, but watertightness at the bottom of the gate is secured by means of two leather flaps bolted to the reinforced concrete through the top edge with $\frac{1}{2}$ in. bolts and over-lapping the sill of the gate recess about 5 in. The pressure of water forces these into close contact with a timber facing strip attached to the concrete sill and the gates are quite watertight. The inner of the two flaps (about $\frac{1}{8}$ in. thick) is acting at low heads of water when the force is not sufficient to move the thicker flap (about $\frac{3}{4}$ in.). At higher pressure the latter is, however, forced tight against the sill and is capable of standing the full 14 ft. head of water. Should the thin flap for some reason or other give way, the thick flap will act as an emergency tightener and close up by the rush of water.

At the heel post where the flap would foul the sill when the gate is opened a loose piece of leather is fixed and is pulled up out of danger by a rod operated from the gang-way.

The gates are opened and closed by horizontal poles fixed on supports at the heel post and at the centre of the leaf similar to those used on canal gates. To ensure correct mitreing, stops are fixed on the abutments so that the leaves cannot be closed too far, and a hinged locking plate is attached to one leaf engaging with vertical bars built in the other.

Two lifting eyes are cast in each leaf to facilitate unshipping in case of necessity.

The dry dock is filled through sluices in the gates. These are 12 in. square and one is fitted in each leaf towards the mitre post and about 1 ft. above the sill. The concrete is stiffened round the sluice with $\frac{1}{2}$ in. diameter rods, the verticals being carried to the ribs above and below. The paddle and guides are of timber and the edge of the concrete round the openings is faced with $\frac{1}{4}$ in. steel plate flanged to fit. The valves are operated by means of a hand wheel from the gangway, the top ends of the rods being supported in a reinforced concrete post.

The gates were erected in position, a temporary dam of earth being left on the main dock side until after testing, which was carried out by water introduced between the temporary dam, the test head being 1 ft. above Trinity High Water.

The drawings were prepared by Messrs. Christiani and Nielsen and approved by the Chief Engineer of the Port of London Authority after the necessary amendments to the original designs had been made. These consisted mainly in the introduction of horizontal and vertical ribs and modifications to the top and bottom bearings.

These gates were not designed for frequent operation, and were only used when it was necessary to float out the concrete barges which were constructed inside the dry dock.

DISCUSSION.

The President, in opening the discussion, said that until one saw the slides and heard Mr. Deane's lecture one hardly realised the extent to which reinforced concrete had crept into use in dock work. Indeed, it seemed that we could not do without it, and in years to come its use would spread more and more.

Mr. F. E. Wentworth-Sheilds, O.B.E., M.Inst.C.E., in proposing a hearty vote of thanks to Mr. Deane for his paper, said he supposed that one of the things we had to thank the war for was that it really did make us rack our brains to find new uses for reinforced concrete. We were able to get a certain amount of steel, as well as gravel and a little cement, but not very much, and at the same time we found it almost impossible to get steel sections and timber, even at the prices which were charged for these luxuries, so we set to work and did what we could with our concrete materials and our round bars, and Mr. Deane had shown that we had managed to make some practical things out of this combination. He was very interested in the large hollow monoliths, referred to in the early part of the paper, and also the references to the monoliths used at Tilbury. Although he himself had not had the opportunity of making reinforced concrete monolith's he had several times looked into the question, and he was inclined to agree with the author that, on account of the trouble and expense involved, for a structure like a gravity wall, whether hollow or solid, the cheapest way in ordinary circumstances was to build it of plain concrete in the form of blocks or in the form of a mass. But when they had to build a wall in deep water, which meant that they had to carry their materials out into deep water somehow, and especially where the foundations were of doubtful material, it was quite likely, it seemed to him, that the reinforced concrete caisson would rival other designs, because it was possible to make that caisson on shore and then float it out to its final position, and therefore avoid the use of expensive stages or cranes to handle the enormous weights. In that way they could get very large caissons or large sections of wall into their final positions with the least possible trouble and expense. On that account there was no doubt that in such a case reinforced concrete was a very serious rival to the old-fashioned solid wall construction. In respect to reinforced concrete groynes, he had always understood that one trouble with them was that they were liable to fret away by the travelling shingle on the beach. With regard to bollards, he was very interested to see these made with reinforced concrete, and there was a good deal in what the author had said with regard to the superiority of the old-fashioned cast-iron bollard. They would probably be interested to know that the bollard which his firm had designed for the White Star Dock at Southampton, where some of the largest ships in the world were constantly docking, consisted of a hollow cast-iron casing containing what might be called reinforced concrete, i.e., it was filled up with concrete reinforced with nickel steel sections, railway rails as a matter of fact, and the great strength of that bollard was principally due to the reinforced concrete. It was designed to stand a horizontal pull of 50 tons, as it was estimated that such a pull might be exercised by a ship of the dimensions of those used to-day, and the only way to satisfactorily make bollards strong enough to resist that pull was by filling the hollow iron casing with reinforced concrete.

Mr. H. K. G. Bamber, J.P., F.C.S., etc., said he had detected a tone of sadness in the author's remarks when describing the methods of construction which might be adopted when there was not enough cement to be got. That sadness was also echoed in Mr. Wentworth-Sheilds' remarks, and perhaps it would be a grain of comfort to Mr. Deane and other engineers and contractors to know that those who govern the destinies of the cement industry were hopeful, if not hampered by Government interference, that during next year they will have completely got over the terrible dislocation of industry caused by the war, and would be able, not only to reach their pre-war output of cement, but considerably exceed it. Therefore, if that was possible, Mr. Deane and others would not have to worry themselves about getting out special designs of constructon in which to make docks if an ample supply of cement were not obtainable.

Mr. A. T. Walmisley, M.Inst.C.E., said that Mr. Deane had the advantage of a sheltered position, as he had said that the reinforced concrete gates were not used every day. He had adopted a very good form in the wall being circular to equalise the pressure on the level. With regard to concrete groynes, he personally was not in favour of them generally speaking. They were built, perhaps, at an angle of 1 in 10, and sometimes required either lowering or raising to suit the accumulation of beach, and this could be done much more easily when they were constructed of timber.

Mr. C. S. Meik, M.Inst.C.E., said that the most interesting point in the paper to him was the question of dock gates. He had never seen any reason why a dock gate should not be made of reinforced concrete, and why the fittings, not only the heel post but the cill and the way the gate fitted up against the cill, should not be the same as in the case of a steel gate. He took it that the leather flap to which the author had referred was merely a temporary arrangement, because he understood the gate was only constructed to satisfy a temporary need. He did not see why the gate should not be made like a steel gate, but the weight had to be taken into consideration. The weight of a wooden gate was very much less, and with steel gates the weight was almost taken up by the flotation of the gate in many cases, and that was the reason why steel gates had been so universally adopted for large entrances. In the gate shown on the screen there was no roller; the gate was simply supported on the pintle and hung from the anchor posts. That principle should be adopted in all gates. He had always put a roller under them, the reason being not that the weight came on the roller when the gate was in—it should come on the pintle and on the anchor posts—but in case the gate became water-logged. In that case, however, the remedy created the disease, because the man in charge of the rollers never knew when the gate was water-logged; the best part of the weight was on the roller paths when it should have been on the anchor posts. That was what happened to the old Victoria Dock entrance, which was now, apparently, in process of being put right, but it was going to be a most expensive process. In some of the Continental ports rollers had been dispensed with altogether. He had found a great deal of difficulty in connection with the wear of the roller path due to the surface of the roller path being planed so that the action of the sea water commenced as soon as the path was submerged. If the cast iron was not planed the surface remained intact and the roller paths lasted very much longer. With regard to Mr. Wentworth-Sheilds' remarks on the question of wooden v. reinforced concrete groynes. On the south coast, where groynes were mostly used, there was a very heavy travel of shingle, and whether they put down concrete or timber there was a considerable amount of erosion. This also applied to piles for promenade piers, and while he agreed that with timber the gravel and sand wears it away and in time makes it smaller, in the case of reinforced concrete, once the skin breaks away the sea water gets to the steel and the pile is done. The only thing to do in these cases was to put a very much heavier covering over the steel and make the concrete very much stronger.

Dr. E. H. Salmon, on the question of floating docks, said the author had mentioned that the cost of maintenance enormously increased the cost of working floating docks. With the ordinary steel dock he himself did not think that remark was quite justified. He had heard that the average cost of maintenance of nine floating docks over a period of fifteen years worked out to about 1 per cent. per annum of the capital cost, which he did not think was a very large amount. He had recently had some correspondence with the engineers of the Amsterdam Dry Dock Company, in which it was stated that the first dock made for Amsterdam was forty-two years old and had never been self-docked for repairs; it was in perfectly good condition, and was expected to last for twenty years. In that case, certainly, the cost of self-docking docks was not very large. There was another point in regard to the capability of self-docking reinforced concrete docks. Although it might not be necessary to lift the dock out of the water for painting very often, it might be necessary to get the dock out of the water in order to repair the under-water portion. The question of making floating docks out of steel that would not rust was also very important. During the war he had had the pleasure of designing an 8,000 ton reinforced concrete dock, and possibly the results arrived at might be of interest to the members. A reinforced concrete dock of any size, roughly speaking, weighed about as much as the ship. It would weigh three times as much as a steel dock of equal capacity. Nevertheless, there was a considerable saving of steel, and in a small dock probably 50 per cent. of the weight of the steel would be saved, in a large dock probably not more than one-third, and in a dock of 12,000 tons they would not save any at all, i.e., there was as much steel in a reinforced concrete dock of that size as in a steel dock. There was a point he would like to mention about the depth of the 8,000 ton dock. It had a depth of 15 ft., whereas a steel dock of similar size would have had a depth of 10 ft., and that meant dredging another 5 or 6 ft. in order to make the reinforced concrete dock possible, which necessarily increased the cost.

THE LECTURER'S REPLY.

Mr. H. J. Deane, in replying to the discussion, said that the fretting away of the concrete in groynes and all structures subject to the action of the sea was one of the most difficult things the engineer had to deal with. He agreed that the proper thing to do was to make the outside skin as hard as possible, and there was a great deal more to be done in the direction of finding out what was most suitable. He had had some experience with sewers in London. In the case of one large main sewer the bottom of which was originally made of Staffordshire blue bricks set in neat cement he had found that the bricks had been worn away and the cement was left standing up rigid, which testified to the strength of neat cement. He was very interested in the bollard at Southampton, which had been referred to by Mr. Wentworth-Sheilds, and he was of the opinion that they might take a leaf out of his book and adopt something of the same character. With regard to dock gates, there had been long controversies as to whether it was desirable to have the gates supported on rollers or not. He had known cases where gates were supposed to have been supported on rollers, but when they were actually lifted the rollers could not be found, and no trace had been discovered as to where they had gone or whether they would come back. It was probable that they would never be seen again. The new gates for the Albert Dock were designed some eight or nine years ago or more, just after the Port of London Authority came into being, and when there was a very great pressure of work with a view to getting a number of improvements put in hand as soon as possible, and consequently there was not time to give that careful consideration which would have been necessary before deciding definitely to abandon the use of rollers under the gates. In the new scheme for the improvement of the Millwall Docks, where the entrance lock is 100 ft. wide and the depth 45 ft., the gates are designed without rollers. The anchorage is designed to take the full weight of the water-logged gates, with a certain amount of mud in the gates. He thought that was the right thing to do, because roller paths were a particular source of worry. Coming back to the question of groynes, the Local Government Board allowed twenty years for the repayment of loans for concrete groynes as compared with ten years for timber groynes, and he supposed that was done with a certain amount of knowledge behind it.

The President announced that the next meeting would be held on January 13, 1921, at 7.30 p.m., when Mr. H. Kempton Dyson would read a paper on "Tests on High Tensile Steels." Mr Dyson had been for many years the Secretary of the Institute, and had done a great deal of work in establishing the Institute, and he trusted that the members would give him support in recognition of the work he had done for them. He also announced that the Library and Reading Room of the Institute would be open for the use of members for an hour before the meeting for those who were forced to wait about.

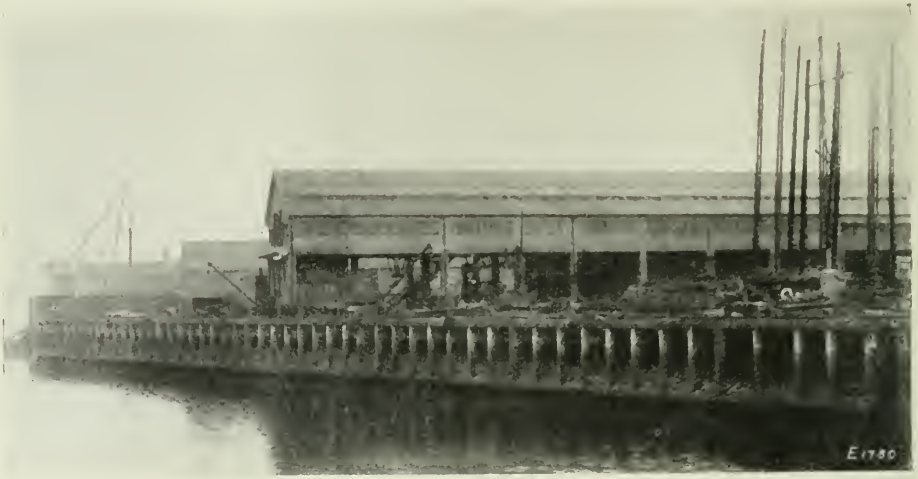


Fig. 1. General View of Wharf.

A REINFORCED CONCRETE WHARF FOR MESSRS. CRAIG, TAYLOR & CO., LIMITED, AT STOCKTON-ON-TEES.

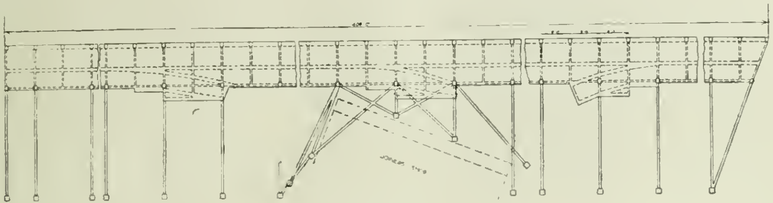
By A. C. MESTON, Licentiate, R.I.B.A., M.C.I.

A structure presenting several interesting problems has recently been completed at Stockton-on-Tees in the shape of a wharf for Messrs. Craig, Taylor & Co., Ltd. The length of the wharf frontage to the river is 408 ft., and the overall width of the deck is about 12 ft. A railway track had to be provided for to enable cranes to be moved to any part of the wharf for purposes of loading and unloading the vessels lying alongside. The weight of these cranes together with the load they are capable of lifting is approximately 40 tons each.

The wharf is built upon reinforced concrete piles. The piles along the front of the wharf are 16 in. by 12 in. in section and 29 ft. long, and are driven at 8 ft. centres. The piles along the inner side of the wharf are of similar section but 34 ft. long. The length of these piles was necessitated by the nature of the ground. Two trial piles of timber which were driven before the concrete piles were cast did not obtain the required set until they reached about 16 ft. below the dredged level of the bottom of the river. The back row of piles was driven at 16 ft. centres. The wharf is tied back at 16 ft. intervals to "dead man" piles, which were driven 30 ft. from the inner face of the wharf. These piles were 18 in. by 18 in. in section and 15 ft. long. Immediately behind the front row of piles, and extending right along the wharf, reinforced concrete sheeting piles 18 in. by 7 in. in section and 21 ft. long were driven. After driving, the top 2 ft. or thereabouts of the main piles was cut out exposing the steel, and the reinforced concrete columns carrying the decking of the wharf were carried up from these.

The tops of the sheeting piles were also cut away about 12 in. and the exposed steel was incorporated with the beam running along the front of the wharf at the top of the main piles. The sheeting piles are designed as propped cantilevers, the reaction at the top of these piles being taken by the horizontal beam at the lower end of the sloping slabs. The reactions from these beams are in their turn taken up by the 16 in. by 8 in. sloping beams shown on the drawing, which are tied back by the land-ties to the " dead man " piles.

The general arrangement of tying back the wharf by land-ties had to be somewhat altered at one portion of the wharf, owing to the proximity of an existing building. This will be seen on reference to the plan, *Fig.* 2, and the general arrangement of ties provided in this portion is indicated clearly on the plan.



PLAN OF WHARF
Fig. 2.

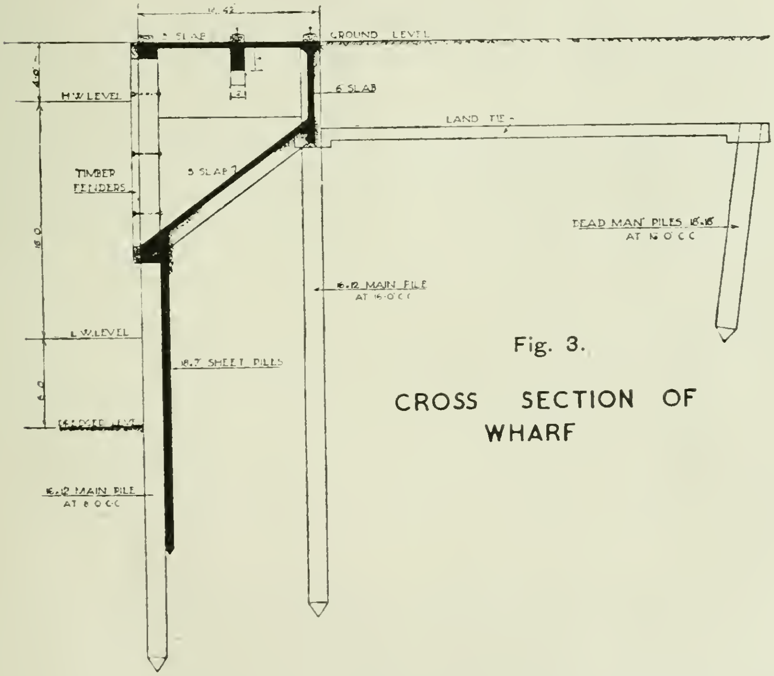


Fig. 3.

CROSS SECTION OF WHARF

Though it was impossible to drive piles inside the existing building it was found possible to carry one of the ties underneath the floor of this building.

Holes were cast in the columns and beams along the front of the wharf to allow for bolting the timber fenders and rubbing pieces to the concrete work.

The whole of the work was on the Kahn system, designed by the Trussed Concrete Steel Co., Ltd., of 22, Cranley Gardens, South Kensington, S.W. ; the contractor who carried out the work was Mr. H. M. Nowell, of Stockton.

SIMPLE RULES FOR CONCRETE ROAD CONSTRUCTION.

SINCE Portland Cement has been manufactured and used in commercial quantities in connection with construction work, the cement itself, the aggregate, and the result of the concrete have been the subjects of careful study through thousands of tests by engineers and chemists throughout the entire civilised world. Whole volumes have been written as to types of cement, sand, aggregate, the amount of water, and, in fact, all phases of concrete work, but too frequently this information is studied by engineers only, and the man who is actually doing the work on the job is left in at least partial ignorance as to the best methods of making concrete and the reasons why other methods will not secure as good results.

Now, however, that concrete roads are being adopted to a much wider extent than hitherto it is essential that all who are engaged in the work should be in possession of such information as will enable them to carry out the operations in an intelligent and efficient manner, and that they should be impressed with the importance of neglecting no single means for the production of good concrete and a sound structure.

Concrete roads to be economically possible must be laid in comparatively thin slabs of 6 in. to 8 in.

In addition to the properties required of concrete in ordinary building construction, concrete roads must withstand great impacts, must resist the abrasive action of traffic, and must be able to withstand wide temperature variations, the direct action of frosts and rains, and to do this without undue wear or cracking.

This means that any defects, no matter how small, in concrete roads are very quickly made evident by their failure, and failures in concrete roads, unless immediately repaired, start to wear in what would otherwise be perfect parts of the road.

With due regard to conditions encountered in actual practice and to the necessity for adapting ideals to practical materials and methods, the following simple rules, if carefully observed, have been found to give perfect concrete roads without materially increasing their initial cost.

SUB-GRADE.

Be sure that the sub-grade on which the concrete road is to be laid is thoroughly compacted and that an ample drainage system is provided.

MATERIALS.

Use only clean, sharp sand and clean gravel or hard crushed stone. There are certain other materials which can be used for large aggregate, but the availability and relative cheapness of gravel or crushed stone make them the ideal aggregate for most jobs. The initial cost of clean materials is only very slightly greater than the cost of unwashed and ungraded materials.

THE PROPER MIX.

Depending upon the type of road and the amount of traffic, work out the proportion to be used. Having once determined the proper mix, make arrangements so that this proportion will be rigidly adhered to in each batch. Numerous ways of automatically measuring cement, sand, stone and water are now on the market, or if these are not available, home-made devices can be substituted and equally good results secured. In general, concrete for roads should be of the proportions one part cement to two parts of sand to four parts of stone, and especial care should be taken to see that to these ingredients is added only a sufficient amount of water thoroughly to dampen the entire surface of each particle of the mix ; any surplus water is an actual detriment to the strength of the concrete.

THE NECESSITY OF THOROUGH MIXING.

Be absolutely certain that each batch is thoroughly mixed and is uniform throughout. The best results can be secured most cheaply and economically by utilizing one or other of the numerous types of batch mixers, since the use of such mixers does away with the possibility of error, which is a necessary part of all manual work. However, the best of concrete can be secured by hand mixing provided someone constantly supervises the mixing and sees to it that the mass is cut over and over and over until the sand, stone, cement and water are thoroughly incorporated.

DEPOSITING AND CONSOLIDATING THE CONCRETE.

As soon as the mixing is complete the concrete should be deposited in approximately its final position as rapidly as possible, and immediately following this it should be thoroughly consolidated. The transportation of the concrete from the mixer or mixing board to its final position can be done in various ways, perhaps the quickest and most economical method being the use of a chute, or trolley and bucket, such as are attached to a great many of the concrete mixers which have been especially built for road construction. The use of one of these mechanical devices does away with the delays which usually follow on a dependence on men with wheelbarrows.

In consolidating concrete, by far the best results are secured by the use of mechanical tamping and finishing machines which automatically screen, tamp and finish the concrete in a very short space of time. It has been found that the use of these machines gives a road which is of uniform strength throughout and does away with the weak spots, which are almost inevitable when this is done by men with tamping tools or rollers. As in mixing, just as good results can be secured by manual labour but at a very much greater cost and only under constant supervision. The objects of the requirement for speed in depositing and consolidating the concrete are two-fold. Getting the concrete into final position and thoroughly compacted with all possible rapidity means taking full advantage of the entire strength of the cement. This is not the case where an appreciable length of time elapses between the start of the mixing and the final finish off. The consolidation of the concrete is all important in eliminating voids caused by such air as may be encased in the concrete and by surplus water which may also be encased in the concrete. Rapid tamping or punning tends to eliminate these voids and to give a dense mass.

GENERALLY.

After the concrete is in position, consolidated and finished, great care must be taken that it is not disturbed and that it is kept covered with some damp covering until it is finally set.

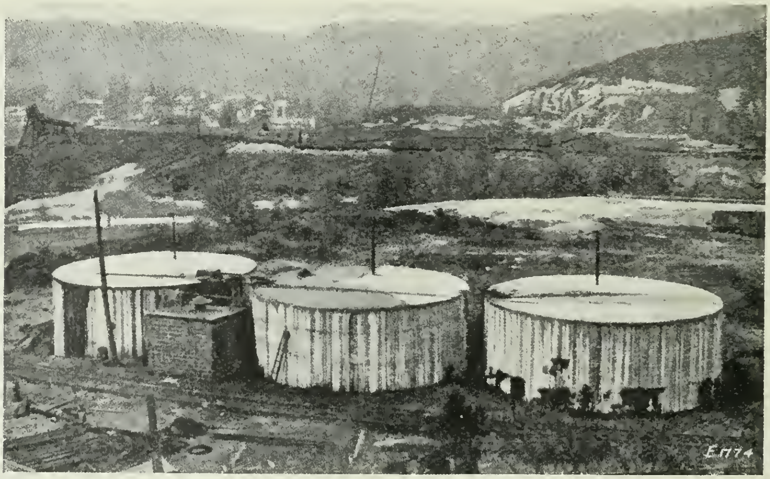
The cost of careful observance of these points means only a few pence per yard added to the initial cost of concrete roads ; failure to observe them or any one of them may and probably will mean a road which will disintegrate under traffic within a very short time. On the other hand, it has been thoroughly demonstrated that careful observance of these principles will result in a roadway which will withstand ordinary traffic for a long period of years with a minimum cost for maintenance, and that throughout its entire life a concrete road will present a smooth, even surface for traffic.

MEMORANDUM.

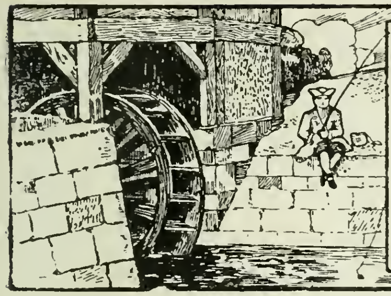
Concrete Tanks Hold Light Flash Oil.—During nearly two years' test, three concrete tanks at the Trafford City foundry of the Westinghouse Electric and Manufacturing Company, U.S.A., have proved satisfactory as fuel oil containers. Recently one of the tanks was used to store transformer oil, and held the light flash oil as easily as the heavy fuel oil.

Each of the tanks has a dia. of 37 ft., with a capacity of 125,000 gals. Built of reinforced concrete, the tanks have successfully resisted the weather, and the little seepage that occurred was easily stopped. A recent inspection of these tanks was made by a representative of the United States Bureau of Standards, in making a study of the use of concrete tanks for storing oil.

These containers, which were built from specifications based on information received from engineers from the Portland Cement Association, have been used to store oil for use both in the foundry and works at East Pittsburgh, Pa.



Reinforced Concrete Tanks for Storing Transformer and Fuel Oil.

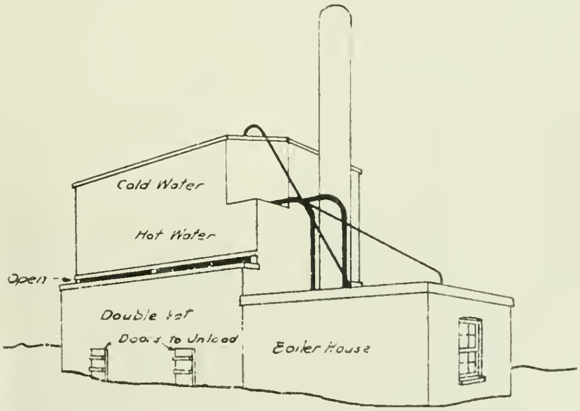


CONCRETE FLAX RETTERY IN BELGIUM

By **WILLIAM WREN HAY**, Assoc. Mem. Am. Soc. C.E.

We reproduce below an interesting description by Mr. William Wren Hay, Assoc. Mem. Am. Soc. C.E., published in "Concrete, U.S.A."—Ed.

A very interesting example of an unusual use of concrete is found in the hot-water retteries constructed in Belgium, along the River Lys. The retting, or steeping, of flax is a very important industry in the neighbourhood of the Franco-Belgian frontier, especially around Courtrai. The large amounts of straw sent here from France and from the contiguous districts resulted in the construction of several artificial retteries,* which hasten the decomposition by the action of hot water and enable a much larger quantity of straw to be treated and at the same time extend the season. The choice of concrete was inevitable for these plants, as the cost of erection must be a minimum and at the same time the nature of the work requires first-class construction. The arrangement usually consists of a series of retting vats with hot and cold water tanks above them. Cold water is pumped into the topmost tank, whence it flows by gravity through a boiler, is heated to about 95° F., and flows into a lower tank or reservoir, from which it is drawn off to the vats below. The vats containing the straw are filled from piping laid along the floor, the water rising through the straw and overflowing at the top. Originally the plants were quite conventional in their arrangement,



Flax Rettery near Courtrai, Belgium.

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* Legrand Van Steenkiste Patents.

having separate elevated steel tanks for hot and cold water, the vats being large pools into which wooden crates containing the straw were plunged by travelling needle carriers. These plants proved too expensive in operation, and the overhead charges ate up all profits, as the competition from the usual hand labour along the river limited the revenue that could be collected. Recognising the possibilities of cheaper construction, these entirely concrete plants were developed, and are now to be seen at several places. The operations are so far simplified through the arrangement of tanks and vats in vertical series in the same structure that two labourers and an engineer or fireman can handle more than 300 tons per season of 8 months. Inspection of several of these plants which have been in use five years or more showed no leakage in general, and several were quite dry inside, in spite of the overflow at one end. When it is considered that during fall weather the outside temperature may be below freezing and the water is kept at nearly 100° F., it is a tribute to the builders and to the materials used. The water of the Lys is practically free from lime, hence its popularity among flax growers. No other care was taken to waterproof these plants other than the usual minute care observed throughout Europe in placing concrete. The vats shown in the sketch have a volume of about 50 cubic metres each, and will hold five tons of straw, being filled four or five times each month. The tanks have a like capacity, or about 15,000 gals. each. The plant shown cost about $3,000 before the war, and has a capacity for retting 500 tons of straw per year.

MEMORANDA.

Seven Subjects we should Know more About.—The American Concrete Institute have selected seven subjects for special study and consideration at the next convention of the Institute in February, 1921.

(1) Standardisation of the contractor's plant for reinforced concrete building construction ; (2) the best possible treatment of structural concrete so as to give attractive results in colour and texture. Contractors are giving more attention than they used to in America to the surface finish of their work ; (3) the housing problem and the use of concrete in aiding its solution ; (4) standardisation of units of design of reinforced concrete building construction ; (5) floor finish ; (6) roads ; (7) the great increase in the cost of timber necessitates a reconsideration of the question of formwork. Steel forms leave something to be desired from the point of view of economy, and their successful use might depend a great deal upon more careful study, and this work will also be in the hands of a special committee dealing with the question of the standardisation of units of design. Nevertheless the reinforced concrete contractor gives more attention than he used to to steel forms.

Concrete for Large Apartment Houses in Washington.—A large apartment house is being erected in Washington of reinforced concrete, faced with brick and limestone. It is being erected in two sections, one section being completed, the work having been carried out in less than seven months. The entire building will contain 1,000 rooms, making 350 apartments of various sizes. The architect is Mr. Philip M. Jullien, Washington, D.C. All concrete is spouted through steel chutes, supplemented by short wood sections. Floors are of concrete joists and hollow tile. Stairways are poured complete with stringers, risers and treads, at the same time as the floor just below. An architectural feature of the buildings is the placing of concrete balconies along the inner courts of every floor.—From *Concrete, U.S.A.*

POPULAR HANDBOOK FOR CEMENT AND CONCRETE USERS.*

Second Edition.)

A Review.

ALTHOUGH the uses of cement and concrete have expanded enormously during the past decade or so, and have extended to farm and estate, home and garden, road and railway, town and country, the literature on this subject has not grown in the same proportion, and it has been felt that there was still a place for a semi-popular book of general type that would prove interesting and, without being too technical, useful, that would bring home to the mind the great economic and artistic qualities of concrete as a building material and help in producing a higher grade of concrete work. These are the criteria stated by the authors in the preface, which have influenced them in the production of the present volume. We welcome this work, therefore, which meets a definite want, and since theoretical methods which have more of an academical interest than a practical value have been omitted, it is essentially a book for the non-technical reader.

The instructions and suggestions in these pages are based upon American practice which, in some directions, is far in advance of our own, and the book, which rightly emphasises the importance of the concrete being of the first quality, is a valuable contribution to the literature of the subject.

The book is divided into six sections and contains thirty-three chapters.

Chapter I is introductory, and serves to show to what extent concrete has entered into our lives. An extract from a speech by the late Mr. Andrew Carnegie, one of the greatest authorities on the production of steel, is worth quoting : " Fortunately the use of concrete, simple and reinforced, is already reducing the consumption of structural steel. The materials for cement and concrete abound in every part of the country ; and while the arts of making and using them are still in their infancy, the products promise to become *superior to steel and stone in strength, durability and convenience and economy in use.*" [The italics are our own.—ED.]

The utilitarian qualities of concrete have long been known and more or less fully appreciated, but its æsthetic possibilities are only beginning to be realised in our own country. In this connection the present book claims, what has for years been advocated in the pages of CONCRETE AND CONSTRUCTIONAL ENGINEERING, the dawn of a new style of architecture ; a style entirely free from the hereditary tendencies of the ancient and mediæval styles, and which could be rendered possible only by the introduction of a new material, possessing properties entirely distinct from those whose possibilities had been studied and studied for ages. The essential features of the new style are pointed out in Chapters IX and X.

Reference is made to the valuable work done in the United States by means of the bulletins issued by the American Association of Portland Cement Manufacturers, by means of which a wide dissemination of the knowledge of the possibilities of cement has been effected. Work in our own country is being carried out on similar lines by the Concrete Utilities Bureau of London.

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* Myron H. Lewis, C.E., and Albert H. Chandler, C.E. Hodder and Stoughton, price 15 shillings net.

Chapter II deals with the different limes and cements, dividing the latter into Portland cements, Natural cements and Puzzolan or slag cements.

The crystallisation and colloidal theories are touched upon but briefly since, while of opinion that the question is of great importance to the cement manufacturers, the authors admit that the subject of cement setting is yet in a controversial stage.

The methods of manufacture of the three kinds of cement occupy about four pages, but special mention is made of White Portland Cement and the materials with which it is mixed to produce white concrete for use in a large variety of specified ways, almost entirely ornamental.

Stress is laid upon the importance of storing cement in a dry place ; if, through the absorption of moisture either from the ground or from the atmosphere it becomes lumpy or even a solid mass, it is useless and should be thrown away.*

In Chapter III the properties and requirements of hydraulic cements are set forth, and the methods that may be employed by the cement user in order to determine whether the material is up to the standard and fit for use are described.

What may be regarded as the subject matter proper of the book commences with Chapter IV—Concrete and its properties.

So much is heard nowadays about the addition of compounds for increasing the strength and density of concrete that it is interesting to note the conclusions at which the authors have arrived. They say " An ideal concrete is a mixture with a minimum percentage of voids. This result is obtained by grading the aggregate and mixing in such proportions that the voids in the coarsest aggregate are filled by a finer aggregate, the voids in which are, in turn, filled by a still finer aggregate, the cement itself being so finely ground that its granules will completely coat those of the finest aggregate. When this condition obtains, the set will produce a mass of everlasting stone."

The function of the water is carefully explained, the general conclusion arrived at being that " The effect of different proportions of water upon the ultimate strength depends chiefly upon the density of the resulting mortar ; the consistency which produces with a given weight of the same materials the smallest volume, after setting, of Portland cement paste or mortar gives the highest strength. Dry-mixed mortars usually test higher than wet after short periods, as they set and harden more rapidly, but more uniform results in practice can be attained with plastic mixtures.

The aggregates—sand, broken stone and gravel—are dealt with in Chapter V and the question of the necessity for " sharp " sand discussed.

The importance of the cleanliness of the aggregate is emphasised in this chapter and simple methods of washing are indicated.

The danger of using natural mixtures of gravel and sand is pointed out, and it is proved that the extra labour required to screen and re-mix the material is more than compensated for by the saving in cement.

Proportioning is discussed in Chapter VI. In this chapter the instructions with regard to water do not appear to agree with those suggested by the results of the researches carried out by Mr. Duff A. Abrahams. We agree that " The principal thing to bear in mind in order to obtain the densest possible mixture is to eliminate the voids in the concrete mass," but the statement that " plenty of water to obtain a wet mix should be employed, as water will drive out the air entrained between the particles of the aggregates " may be true as far as it goes, but any excess of water beyond that required for the chemical changes necessary to the setting of the cement and hardening of the concrete will, when dried out, leave voids. As a matter of fact this is admitted in the same chapter.

" Mix rich and mix wet to obtain the best work " we consider a distinctly dangerous doctrine.

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* Under " Cement Notes " in this issue, the advantage of storing cement in bulk, rather than in sacks, is discussed.—Ed.

Included in this chapter is a simple and practical method for determining the proportion of voids in the aggregate.

Chapter VII. The right note is struck in the opening sentence of this chapter : " The proper mixing and placing of concrete is fully as important as is the proportioning of its ingredients." Within certain limits, our experience is that it may be even more important.

The instructions for mixing the sand and cement are quite sound, but we do not like the method advocated for adding the coarse material and the water when hand mixing is employed. By this method the coarse material is placed on the top of the levelled sand and cement mixture, but is not turned over while dry. The instructions continue :—" Add about three-fourths the required amount of water, using a bucket and dashing the water over the top of the pile as evenly as possible." It is claimed that by this method an extra shovelling is saved. It seems to us, however, that a better result will be obtained by turning over the whole of the mixture dry, and then adding the measured quantity of water, slowly, through a rose, while the materials are being further mixed.

Useful illustrations of home-made tools for the concrete worker are to be found in this chapter and the advantages of the batch mixer over the continuous type are duly set forth.

A method of obtaining an even, homogeneous face to concrete work which is often neglected is that of " spading " the wet material next the " form." This is dealt with in detail.

Concreting in freezing weather is touched upon very briefly and the employment of common salt for lowering the point at which water will freeze is mentioned. This, however, we do not advocate, because in severe weather it defeats the object at which it aims, since the salt has the effect of retarding the setting of the concrete, a result which it is important to avoid. We consider the only safe methods to be those of heating the sand, stone and mixing water, or covering and housing the work while in progress.

Chapter VIII deals with " forms " for concrete construction, most of which are in conformity with ordinary American practice. This includes a formula recommended by Sanford E. Thompson for designing forms.

Chapter IX on the architectural and artistic possibilities of concrete, though consisting of some three pages or so only, contains many passages worth quoting, e.g., " True art is always the result of a clear and forceful expression of the idea and use of the structure."

Then, after discussing the temptation to imitate stone or other construction in concrete, " The future of concrete treated architecturally lies in a development on surfaces and not lines."

Many more extracts might be given from this chapter, but space forbids.

Chapter X deals with concrete residences. This term has a much wider meaning in the United States than in our own country. In the States, the concrete " residence " includes every variety of house from the cottage to the palace. In this country it is, with a few notable exceptions, entirely confined to the cottage.

In Chapter XII various methods for the artistic treatment of concrete surfaces are described, and include, amongst others, rough-cast, pebble-dashing, exposure of the aggregate by scrubbing, etching with acid, tooling, tinting, panelling, mosaics and carving.

This aspect of concrete work has been but little regarded in this country, but those to whom the æsthetic side of constructional work appeals will find that by the adoption of one or the other of the methods described, concrete possesses vast possibilities for artistic treatment which are quite legitimate and which enable it to express its own individuality.

Concrete blocks and their manufacture form the subject of Chapter XIII, and we agree with the writers that concrete blocks should not be used in a building until they are from thirty to sixty days old.

The artistic side of concrete is continued in Chapter XIV, which describes the making of ornamental products, the methods being divided into two general classes, modelling and moulding. This chapter contains much useful information on a little known side of concrete practice.

Chapter XV deals with the manufacture of concrete pipes and fence-posts. In the latter the method of attaching the wire fencing principally adopted in this country, viz., by perforations in the post, is not mentioned in the text.

Section IV, containing Chapters XVI–XXIV, is devoted to the Principle of Design and Construction in Reinforced Concrete, and the explanation of the theory, together with the various tables and formulæ, will be found of great practical interest to engineers and others responsible for the design of important works. The other subjects included in this section are Systems of Reinforcement, Reinforced Concrete in Factory and General Building Construction, Concrete in Foundation Work, Retaining Walls, Abutments and Bulkheads, with a table of earth pressures, and Arches and Bridges.

Chapters XXV–XXIX, which constitute Section V, describe the uses of concrete for special purposes and include Sewerage and Drainage Works, Tanks, Dams and Reservoirs, Sidewalks, Kerbs and Roads, Concrete in Railroad Construction, and the utility of concrete on the farm. With reference to concrete roads and footpaths stress is rightly laid on the importance of a well-consolidated foundation, but the suggestion that the concrete road may be put into service at the end of a week if the weather conditions have been favourable is not in accordance with modern practice.

As might be expected, a large number of ways in which concrete can be employed on the railway are set forth, but American engineers still appear to be in pursuit of the ideal type of " tie " or " sleeper " which will be perfectly efficient under all conditions of traffic. One suggestion put forward in this book, viz., solid concrete road beds for special locations on railways, is well worth consideration.

As on the railway, so on the farm, there is practically no limit to the variety of uses to which concrete may be applied. The most important of these are described in detail in Chapter XXIX and a list of others given.

The last section of the book, comprising Chapters XXX–XXXIII, is entitled, " Important Miscellaneous Data on Concrete Construction," the subject of the first of these Chapters being " The Water-proofing of Concrete Structures." So much has been written in this Journal on the question of water-proofing that little need be said here. We do not agree that, as a general statement, the " striking fault of concrete is its great thirst for water." Of course it is a scientific fact that every substance is more or less porous, but by using a good cement, and with proper care in the selection and cleanliness of the aggregate, in proportioning, mixing, handling and curing, such a high degree of impermeability can be secured as to render the material to all intents and purposes watertight.

Grout, or " liquid concrete," and its uses are dealt with very fully in Chapter XXXI ; and the importance of inspection, and the work of the Inspector, together with a summary of the essential rules and principles for securing good concrete work are treated exhaustively in Chapter XXXII.

The last chapter of the book is devoted to the cost of concrete work, but as the figures do not apply to this country at present prices, comment is not necessary.

CONCRETE IN THEORY AND PRACTICE.

A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.

REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—Ed.

CHAPTER IV.—*continued.*

Shear Resistance of Concrete Beams.

66. Examples of the rules already given will now be worked out in detail.

Fig. 11 (*a*) shows a T beam 16 ft. span carrying a central point load of 10^T.

The centre moment is

$$\frac{WL}{4} = \frac{10^T \times 16' \times 12}{4} = 480 \text{ tons inches.}$$

The area of steel required at mid span

$$A_s = \frac{480}{22'' \times \cdot 88 \times 7\cdot 15^T} = 3\cdot 5 \text{ sq. inches.}$$

6–$\frac{7}{8}''$ diam. rods give $6 \times \cdot 6 = 3\cdot 6$.

If we dispose the bars as in *Fig.* 11 (*a*), the shear resistance will be the same at every section.

The shear is 5 tons = 11,200 lb.

The shear resistance at any section will be the vertical component of the inclined rods, added to the vertical component of the inclined compression in the concrete. This latter, in a symmetrical design like the one given, may be taken equal to that of the inclined rods.

Now the force in the inclined bars is

$$\text{Area} \times \text{stress}$$

$$1\cdot 2'' \times 16{,}000 = 19{,}200 \text{ lb.}$$

The vertical component is therefore

$$19{,}200 \times \frac{bc}{ac}$$

$$= 19{,}200 \times \frac{20}{54''} = 6{,}600.$$

Similarly, vertical component of inclined compression $= 6{,}600$

$$13{,}200$$

In this case stirrups are therefore not necessary. Nevertheless, for several reasons, a few are desirable, and we may therefore adopt the minimum, say $\frac{3}{8}$ in. diameter, spaced apart a distance equal to the depth of the beam, say 24 in.

Note in passing—

(1) These inclined compression forces can only exist when the bottom rods are excellently secured at their ends.

(2) These inclined tension forces can only exist when the inclined rods are excellently secured at their ends.

(3) The stirrup at the support is particularly effective in preventing the hooks from unbending.

(4) The forces can be worked out graphically or otherwise by treating the beam as a lattice girder.

67. Suppose now we consider a beam, of same span and size as before, but with a distributed load of 20 tons.

The moment at midspan will be the same as in the last example, and therefore the same steel will be required.

The shear, however, will now be 10 tons at the end, varying uniformly to zero at midspan, and therefore a different arrangement of rods will be required, giving a greater shear resistance at the end and a less resistance near midspan.

Such an arrangement is shown in *Fig.* 11 (*b*), where the rods at the end are bent up steeply, the next system less steeply, and the centre part having no bent-up rods at all.

In a case like this, it is desirable to calculate the shear and the shear resistance in each of the panels *ab*, *bc*, and *cd*.

End panel ab.

$$\text{Shear} = 10^T = 22{,}400 \text{ lb.}$$

Shear by inclined bars

$$\text{area} \times \text{stress} \times \frac{bf}{af}$$

$$1\cdot 2 \times 16{,}000 \times \frac{20}{28} = 13{,}700$$

Shear by inclined compression $= 13{,}700$

Total shear resistance $= 27{,}400$

This is therefore satisfactory.

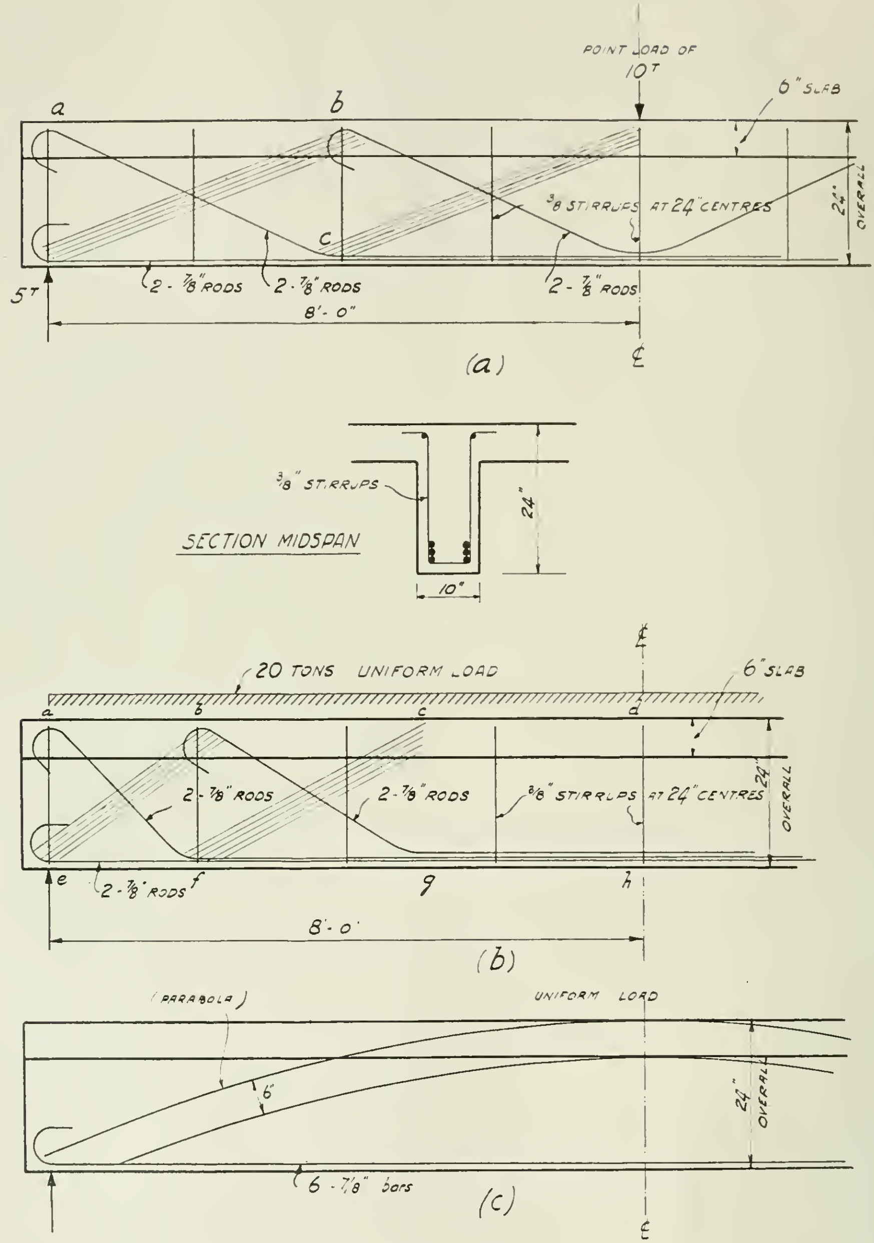

POINT LOAD OF
10T
6" SLAB
a
b
c
3/8 STIRRUPS AT 24" CENTRES
24" OVERALL
5T
2 - 7/8" RODS
2 - 7/8" RODS
2 - 7/8" RODS
8'- 0"
℄
(a)
3/8" STIRRUPS
SECTION MIDSPAN
24"
10"
℄
20 TONS UNIFORM LOAD
6" SLAB
a
b
c
d
2 - 7/8" RODS
2 - 7/8" RODS
3/8" STIRRUPS AT 24" CENTRES
24" OVERALL
e
2 - 7/8" RODS
f
g
h
8'- 0'
(b)
(PARABOLA)
UNIFORM LOAD
6"
24" OVERALL
6 - 7/8" bars
(c)
℄

FIG 11

Second panel bc.

Shear at $b = \frac{3}{4} \times 10^T = 16{,}800$ lb.

Shear resistance by inclined bars

$$= \text{area} \times \text{stress} \times \frac{cg}{bg}$$

$$= 1{\cdot}2 \times 16{,}000 \times \frac{20''}{40} = 9{,}600$$

$$\text{Shear by inclined compression} = \underline{9{,}600}$$

$$19{,}200$$

This is therefore satisfactory.

Centre panel cd.

Shear at $c = \frac{3}{8} \times 10^T = 8{,}400$.

If we rely on diagonal tension, we have safe shear resistance

$$= 60 \times \text{depth} \times \text{width}$$

$$= 60 \times 20'' \times 10''$$

$$= 12{,}000 \text{ lb.}$$

This is therefore satisfactory.

Note.—(1) Both the last examples are what are called by the author " double " systems, in which any vertical plane is cut by an inclined tension *and* an inclined compression. For many reasons, such systems are to be preferred.

(2) The inclined compression must be stressed to over 600 lb./sq. inch. For this purpose, the breadth of the band may be taken at one-quarter the total depth.

Now the force in *eb* is $1{\cdot}2 \times 16{,}000 = 19{,}200$ lb.

The area of the band is

width × breadth

$10'' \times 6'' = 60$ sq. in.

The actual stress is therefore

$$\frac{19{,}200}{60} = 320 \text{ lb./in.}^2$$

which is satisfactory.

The inclined compressions in *Fig.* 11 (*a*) and (*b*) are called " indirect " by the author, as they do not carry the load direct to the support (as in *Fig.* 10 (*e*) or (*f*), but act only in conjunction with the shear reinforcement.

68. It will be interesting to see how much shear the beam would have carried by *direct inclined impression* if no shear reinforcement of any kind had been used, and all the bars carried along to the end, as in *Fig.* 11 (*c*).

Using the rule in par. 65 of 500 lb. per sq. inch, multiplied by the ratio of effective depth divided by the span, we have end shear due to direct inclined compression

$$= 500 \times \text{depth} \times \text{width} \times \frac{\text{depth}}{\text{span}}$$

$$= 500 \times 20'' \times 10'' \times \frac{20''}{192''}$$

$$= 10{,}400 \text{ lb.}$$

In other words, this beam, without shear reinforcement, would have carried a uniform load of 20,800 lb., or nearly 10 tons.

For this purpose, the percentage of steel must not be less than ·675. In our beam it is

$$\frac{3{\cdot}6 \times 100}{20 \times 10} = 1{\cdot}8,$$

more than is required from this consideration.

Note that if, as a rough check, we take the parabolic arch as 6 in. wide, the safe force in it would be

$$600 \times 10'' \times 6'' = 36{,}000 \text{ lb.}$$

The slope at the end is $\frac{18''}{54''}$, or $\frac{1}{3}$, giving a shear resistance of 12,000 lb., agreeing fairly well with the 10,400 from our rule.

As a general rule, it is undesirable to take full advantage of the existence of this shear strength without reinforcement because the parabolic arch in *Fig.* 11 (*c*) crosses the inclined compression forces in *Fig.* 11 (*b*) and therefore the concrete would be stressed twice. It will not be necessary here to consider the exact treatment of such cases. Nevertheless, this strength is often of great importance.

CEMENT NOTES

By Our Special Contributor.

Loam and Clay in Concrete Aggregates.

SPECIFICATIONS for concrete usually provide that the aggregate shall be free from loam and clay, but as there are varying interpretations of what constitutes freedom from loam and clay, and as there are large quantities of concrete produced without the protection afforded by a specification, it will be of interest to consider what happens when certain aggregates are used in the state that nature presents them.

The strength of concrete lies particularly in the adhesion of the cement to the aggregate, but if the latter is surrounded by a film of loam or clay which is not removed during the concrete mixing process, it is certain that although cement may adhere to the film, the adhesion of the latter to the aggregate is negligible so far as the strength of concrete is concerned, and thus the strength of the concrete is reduced.

On breaking up concrete made from unwashed pit gravel, it is generally possible to remove, with ease, pebbles which have little adhesion to the mass, and on examination of the bed in which these pebbles have lain, a film of loam can frequently be detected. Such concrete, when broken up by force, yields a large proportion of pebbles free from adherent mortar, while on the other hand, with a clean aggregate, the disintegration of the concrete involves breakage of the pebbles.

It will be obvious, then, that in the case just considered, of pebbles and sand coated with loam, the proportion of the latter necessary to affect seriously the strength of the concrete need only be trifling, probably 2 or 3 per cent. would suffice. But, take the case of an aggregate in which the loam or clay is not adherent to the sand and pebbles, but is in the form of mud disseminated throughout the aggregate and not coagulated. In such a case it is probable that the effect upon the strength of the concrete may be merely that caused by the greater surface to which the cement particles are called upon to adhere. There must of course be a limit to the proportion of loam or clay that can be present without damage to the cement, but this hypothesis explains why it is possible in some cases to add clay to concrete without any harmful effect.

From these preliminary considerations it can be understood that in practical experience a pit ballast containing as much as 20 per cent. of loam can sometimes produce a good concrete, while another pit ballast, containing no more than 5 per cent. of loam and used under similar circumstances, may yield a very poor concrete. It is often difficult to convince a Clerk of Works that because he has used an obviously loamy ballast with success on one contract, he may not necessarily be able to use a less loamy material with an equal hope of success.

What, then, should be the criterion when determining the suitability of sand or gravel for concrete ? Obviously the best test is the crushing strength of cubes composed of the material under examination with a cement of known quality. The usual test of shaking the aggregate with water in a graduated glass cylinder and observing the proportion of loam or clay after settlement is also a useful one, and any material containing more than 10 per cent. of such impurities should be scheduled as requiring washing; but this test does not reveal the aggregates with strongly adherent loam, which are so undesirable. Lumps of coagulated clay can usually be seen by examination with the eye, and such aggregate should be excluded unless the lumps can be removed by washing.

A common effect of a loamy aggregate is to retard the hardening of the concrete, and this effect is generally more marked in a cold, damp atmosphere than under warm dry conditions. Such concrete is of course more liable to damage by frost than a quick-hardening concrete.

It is a curious fact that some cements yield better results than others when used with loamy aggregates, and it is not uncommon for a contractor to find that two brands of cement (both complying with the British Standard Specification) yield markedly different results with the same aggregate, one cement giving a satisfactory result as judged by the eye, and another producing a slow-hardening concrete which may in winter take several weeks to reach a reasonable strength. The cause of this difference requires elucidation, but it appears that quick-setting and quick-hardening cements are less liable to the deleterious effect of a loamy aggregate than slow-setting and slow-hardening cements.

The Portland Cement of the Future.

The issue of a new revision of the British Standard Specification for Portland Cement recalls the conditions of twenty years ago when cement manufacturers had a dozen or more specifications in their Specification Books and were producing half a dozen different varieties of cement to satisfy their customers' varied tastes.

In those days, the cement salesmen bravely accepted any specification offered to them, and cement works executives strove to fulfil them. The test variously known as "immediate immersion," "cold plunge," or "sudden death" was one of the chief terrors, and when combined with a slow-setting specification required great ingenuity on the part of the tester before a satisfactory result could be displayed. The "bottle test" and "rise in temperature test" were other items of specifications at the beginning of this century which have now happily been abandoned.

The British Standard Specification of to-day is not ideal but it possesses the confidence of cement users and cement manufacturers, and at least serves the purpose of excluding weak and unsound material. It is hardly to be doubted, moreover, that any general improvement in the quality of the cement produced in this country will depend upon the alterations made from time to time in the Standard Specification, or in other words, the Portland Cement of the future will depend upon the Standard Specification.

Improvement in tensile tests is an obvious development likely to occur, and from the fact that cements are already on the market with higher tensile tests at seven days, both neat and sand, than demanded by the Standard Specification, it is reasonable to conclude that the specification of the future will set higher limits. Cement of such strength should, of course, enable the constructional engineer to economise in the dimensioning or proportioning of his concrete.

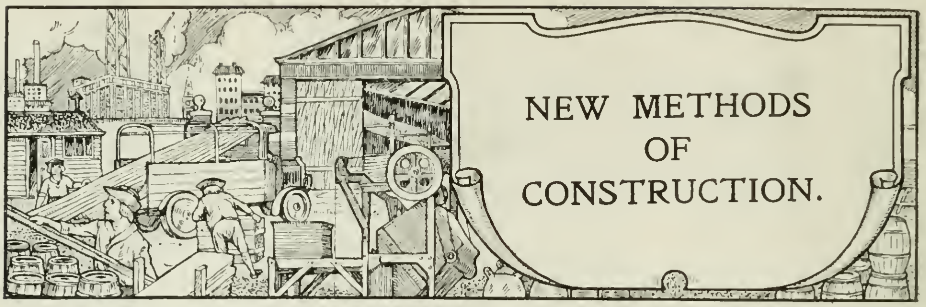
Another improvement which might well be standardised is the faculty of rapid hardening. Under present conditions, so long as cement develops a certain strength at seven days, it is regarded as satisfactory, the rate of gaining strength during this period being ignored by specifications although of great importance to cement users.

Slow hardening is a frequent complaint of concreters, and those who have investigated the subject in the laboratory know that this behaviour of concrete is to some degree attributable to the cement, even though the latter may comply with the British Standard Specification. The neat tensile strength of commercial cements at 24 hours may vary from 150 lb. to 350 lb. per square inch and the hardness of concrete at the same age would vary accordingly.

The value of a rapid hardening concrete is self-evident and any improvement in this direction would be of great advantage to the cement user. A neat tensile strength of 400 lb. per square inch at 24 hours is not unattainable, and it is possible that the Standard Specification of a decade hence may contain some such provision.

Fineness of grinding is another property of cement which may be the subject of improvement in the future. Cements with residues of 3 per cent. on the 180 mesh sieve are already well known, and if better air-separating apparatus be devised for cement grinding there is no reason why even this fineness should not be improved upon. Finer grinding will of course tend to bring about the rapid hardening and the high strength at seven days already discussed, and it is conceivable that as fine grinding is practically no more than a means to an end, the Engineering Standards Committee of the future may be content to set the strength limits and leave the fineness and other means of obtaining the strength to the discretion of the cement manufacturer.

The soundness of cement is a quality in which no improvement seems to be necessary. The present standard—the Le Chatelier test—has proved by experience to be an adequate protection against expansive cements and no good purpose would be served by reducing the limits of expansion now contained in the Standard Specification.



NEW METHODS OF CONSTRUCTION.

In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.—Ed.

THE HESSIAN FABRIC SYSTEM OF CONCRETE CONSTRUCTION.

Under this method, which presents some novel features, the walls are erected *in situ* by means of wooden moulds which are raised course by course until the wall is complete.

The speciality of the system and that which gives it its name is that when the shuttering is set for each course, before being filled with concrete the whole of the mould is lined with very coarse "Hessian" with sufficient left over at the sides to wrap over the top. Thus it will be seen that each course is entirely encased in the fabric, and that when the moulding boards are removed the fabric covers both the inner and outer faces of the wall.

If the wall is to be plastered, rough-cast or rendered the fabric is left in position, in order to provide a better key for the added coat.

It is stated that Hessian fabric does not rot when bedded in cement.

To the moulding boards fillets are attached, in order to produce on the wall the appearance of bonding joints, and so to imitate stonework. If no external after-treatment is intended the Hessian is cut away with knife or scissors.

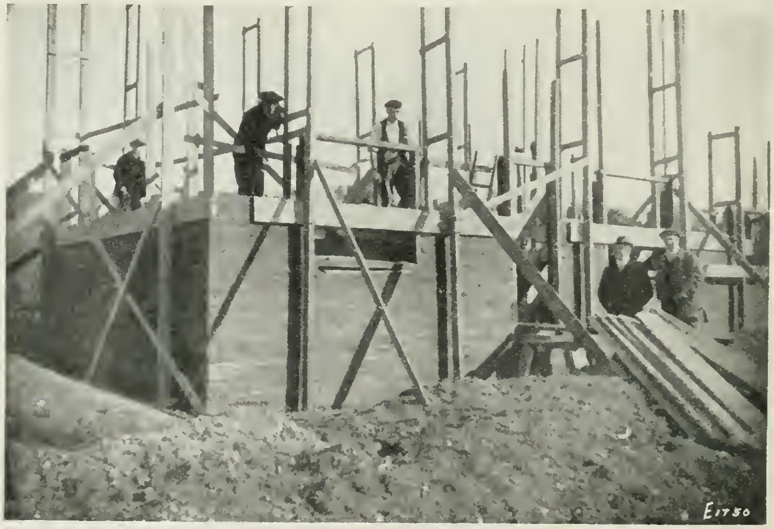


Fig. 1. This Photograph shows the Scaffolding Arrangement for supporting the Wooden Moulds.

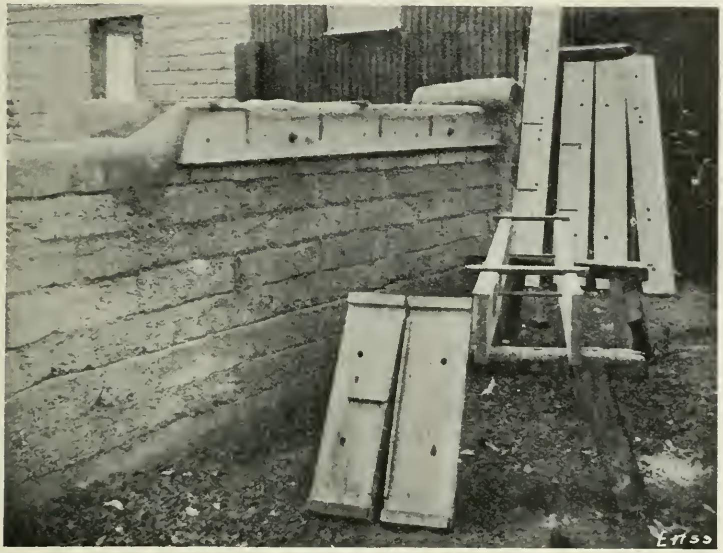


Fig. 2. Showing the Method of Erecting a Solid Wall. The Hessian Fabric is seen, laid between the Moulding Boards before the Concrete is filled in. In the foreground are the Moulding Boards with Fillets attached.

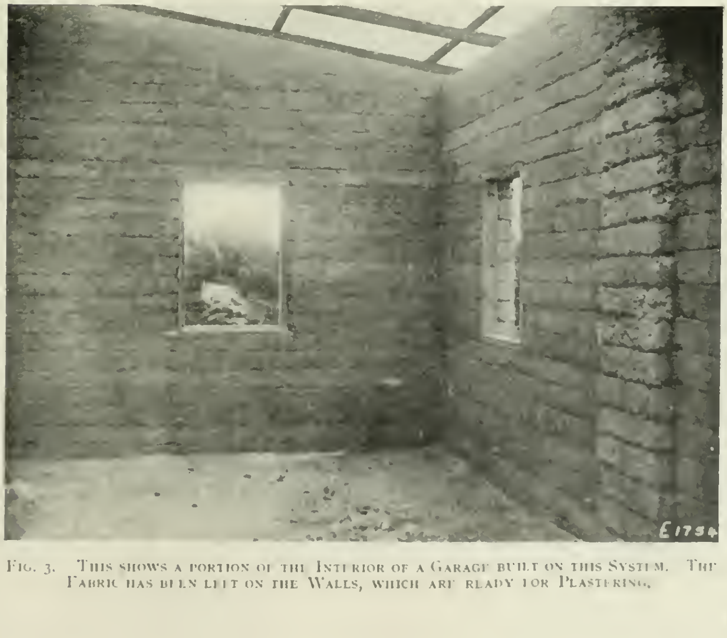


Fig. 3. This shows a portion of the Interior of a Garage built on this System. The Fabric has been left on the Walls, which are ready for Plastering.

The real object of the fabric is to hold the concrete together when the moulds are removed, which is done immediately they are full and the fabric bedded down on the top.

Cavity walls may also be built on this system. In this case cores are placed in the mould after the fabric has been placed in position, each two lengths of core being separated by a space. The concrete which fills these spaces forms a concrete wall-tie. The cores are removed before the outside boards are taken down.

It is claimed that the fabric, by crossing the cavity, prevents the latter being filled up at the bottom with mortar as is often the case in building cavity walls.

For ordinary cottages it is said that the whole of the work can be done from the inside of the building with the aid of a few trestles.

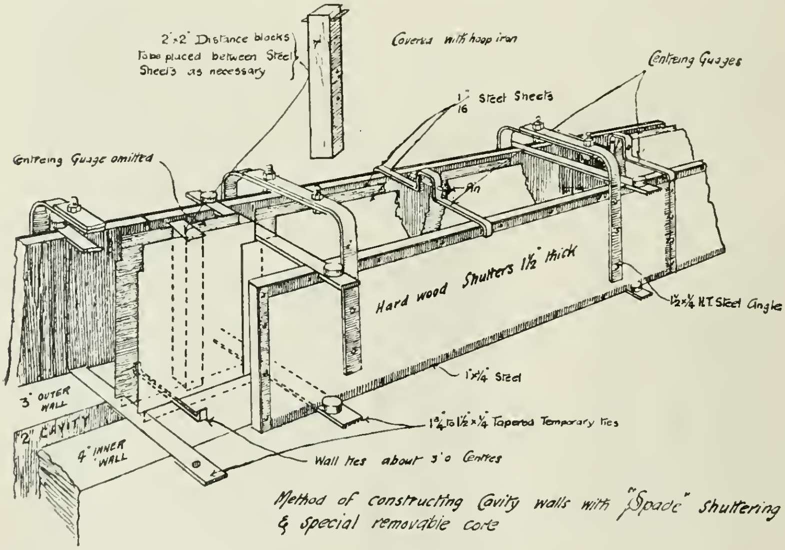
In erecting a house, after the foundation is laid, pairs of wooden verticals are set up all round the site, one of each pair being on the outside and one on the inside of the wall. The verticals are perforated with holes at 12-inch centres. These holes which, in the case of each pair are in register, are for the accommodation of the bolts which hold in position the moulding boards which lie on the inner sides of the uprights. The arrangement is seen in *Fig.* 1. When the moulds are full the bolts are removed, the boards raised for the next course and the work resumed.

The promoters claim that four labourers mixing concrete and one man and one boy building will complete a wall containing an equivalent of 3,000 bricks in a day of eight hours.

The system, the patentee of which is Mr. J. Clements of Northfleet, has been approved by the Ministry of Health, provided the Ministry's specification for concrete work is complied with.

A NEW SYSTEM OF SHUTTERING.

ONE of the results of the increased cost of building has been the reduction to an absolute minimum in State-aided housing schemes of all artistic adornment and architectural features which are designed solely to add to the charm of the houses, and do not fulfil some utilitarian purpose. With four- and five-room houses averaging from £900 to £1,000 each, this, although much to be regretted, can hardly be taken exception to; but, as has been frequently pointed out, concrete lends itself particularly well to artistic treatment without any extra expense whatever being incurred.



Method of constructing Cavity walls with "Spade" Shuttering & special removable core

FIG. 1.

This result is obtained in a variety of ways, some rather complicated and some extremely simple.

A very simple and ingenious method is used in connection with the "Spade" system of shuttering, invented and patented by Mr. A. L. Woodward, of Ardmay Hotel, Surbiton. As will be seen in *Fig.* 1, the shuttering consists of pieces of hardwood held together and kept at the required distance apart by steel angles. When a cavity wall is being built, a core of two sheets of steel is inserted, and held in position by distance blocks and a centering gauge. The shuttering is kept true as the succeeding courses are being built by temporary ties being placed across the last completed course, and removed when the shuttering is removed. Wall ties are built in at each course as the work proceeds. Each course is built its entire length at one operation, so that there are no vertical joints. The shutters are made in four lengths, between 4 ft. 6 in. and 3 ft. 2½ in., and combinations of sets of these shutters will give several hundred different dimensions between 3 ft. 2½ in. and 50 ft., so that there is no difficulty in working to different plans.

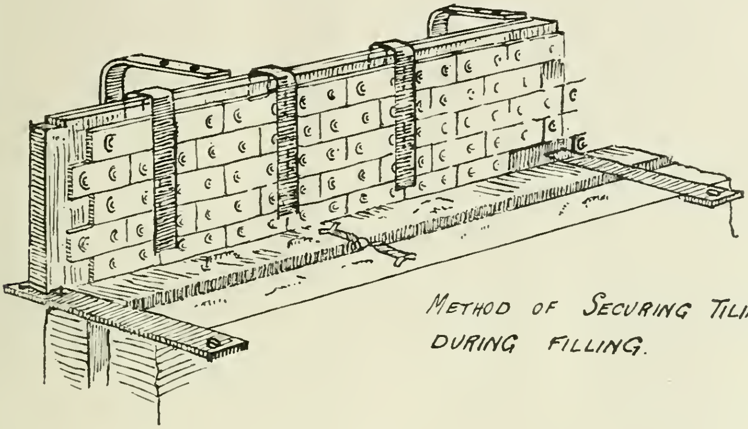


FIG. 2.

Perhaps the most interesting feature of the system is the method adopted for obtaining various exterior finishes. *Fig.* 2 shows the method of obtaining a tiled surface without any labour being required beyond that necessary to build the wall. The tiles are placed inside the shuttering and held in position by strips of hoop iron while the concrete is being filled in ; when the shuttering is removed they, of course, adhere to the wall. In a piece of walling which we had an opportunity of inspecting tiles had been built in this manner as a surround for a fireplace, and appeared to be quite satisfactory. On another section of walling a mould had been used in the shuttering which gave the appearance of ordinary brickwork, properly pointed, which had not been touched after the removal of the shuttering. To give the appearance of rough-cast a piece of ordinary matting is used inside the shutter. By these methods excellent reproductions can be obtained of stonework, and even weather-boarding, without incurring any extra expense or labour beyond placing the mould in position inside the shuttering. This system eliminates all supporting piers, posts and struts, whether permanent or of a temporary nature, and the shutters can be erected to the required dimensions without the aid of measuring instruments or gauges. The system will shortly be used by two public bodies in connection with housing schemes.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Reinforced Concrete Design. Vol. II. Practice. By Oscar Faber O.B.E., D.Sc., A.M.Inst.C.E.

London: Edward Arnold. 246 pp. demy 8vo. 18s. net.

Any publication upon Reinforced Concrete by Dr. Faber deserves careful consideration by structural engineers because he is one of the comparatively few engineers who have had the advantage of advanced theoretical training and scientific research combined with considerable practical experience under commercial conditions. The present book consists of an extended treatment of certain portions of the original book on Reinforced Concrete Design which Dr. Faber wrote jointly with Mr. Bowie some years ago.

Dr. Faber holds strong views in particular upon two problems arising in reinforced concrete design: one of them is concerned with the bending moments in columns arising from monolithic construction, and the other is on shear stresses.

The present book consists principally in an extension of the treatment previously given for continuous beams and column bending moments.

The first part of the book (122 pages) is devoted to the determination of bending moments in beams for various arrangements of span and conditions of loading; the formulæ are derived not from the Theorem of Three Moments with which students are now being made familiar but upon what may be termed slope formulæ. The present writer is prejudiced in favour of the "Three Moments" and thinks that Dr. Faber's book would have been followed more easily if this treatment had been given first. This part of the book is an excellent piece of work and should save much time on the part of designers who previously attempted accurately to consider continuous beams and many errors in designs on the part of those who previously used only so-called "practical" rules. The use of "practical" rules is commonly the refuge of the inefficient.

Part II deals with column moments and explains at greater length than formerly the methods of taking account of them. Dr. Faber states that "the author has heard people argue that if they design beams without reckoning on the stiffness of the columns, there is no need to design columns for bending" and that "some so-called specialist firms design without taking their factors into account, some so-called specialist firms also from time to time pay for structures which have unaccountably collapsed."

We hardly think that this innuendo is well placed in a scientific treatise, especially as it is not supported by evidence of collapse which has been proved to be due to bending stresses in the columns. Dr. Faber would be doing a great service to reinforced concrete designers if he could persuade them by verified facts that provision for column bending moments in design is essential. The present writer believes that it is a fact that in by far the greater number of the reinforced concrete structures which have been erected in this country and America no such provision has been made. With the working stresses at present employed, therefore, it does not appear evident that the present methods of design are dangerous. If it is suggested that higher working stresses should be allowed on the columns when provision is made for bending stresses, then the problem is a different one. We understand that Dr. Faber is in favour of adopting higher stresses when secondary stresses are calculated, but we do not find any reference to this point in the book.

In Part III of the book we have first a chapter giving tables of properties of standard columns and beams; then a short but good chapter on live load allowance for rolling goods. This is followed by a chapter on Shear Resistance incorporating the results of Dr. Faber's researches on the subject. There are a number of Appendices, and finally the London County Council Regulations are given with a short note upon four points upon which revision is considered desirable.

The book is one which every reinforced concrete engineer should study; it gives designers access to tables which save much time in calculations and which must have involved the author in many hours of laborious work.

QUESTIONS AND ANSWERS RELATING TO CONCRETE

In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.

Question.—J. L. writes:—In the issue of October, page 701, *Chap. III,* "CONCRETE IN THEORY AND PRACTICE," *you give an example* 6 *in. slab,* 25 *ft. span,* 12 *ft. c.c. or* 10 *ft. between beams. You refer to your table August issue, p.* 567, *with a view to showing its use. At the end of clause* 51, *p.* 701, *October issue, you say as follows:* "*Though our slab* (6 *in. depth*) *is not quite the requisite thickness* (*meaning* 7·2 *in the table*) THIS IS MORE THAN COMPENSATED BY ITS WIDTH BEING MORE THAN REQUIRED. *I cannot follow the meaning of this, seeing that the example given is* 12 *ft. wide or* 10 *ft. between beams and the table specifies* 34·9 *ins.; the distance between beams in the example is* 10 *in. or* 108 *in. Will you kindly explain.*

Answer.—We have read this question several times and there are parts of it which we do not think are clearly expressed. The article says that though the slab 6 in. thick is not quite the requisite thickness—meaning 7·2 in. as shown in the table—this is more than compensated by its width being more than required. The table shows that a width of 34·9 in. is required, that is, something just under 3 ft. 0 in., and if we take as the permissible width a slab one-third of the span as recommended, this would give us something over 8 ft. 0 in., which is, of course, much more than the 3 ft. 0 in. required. The slab in this connection acts, of course, as the compression member of the beam and what is required is a compression member which will carry a certain load or total compression, and it is surely clear that a slab 8 ft. 0 in. wide, 6 in. thick will carry a larger compression than a slab 3 ft. 0 in. wide, 7·2 in. thick as called for by the table.

Question.—May I take advantage of your "Questions and Answers" page to inquire the meaning of the terms "Natural" cement, "Artificial" cement and Portland cement, and wherein lies the difference, if any, between these products?

Answer.—In replying to these questions we will reverse the order and take Portland cement first.

Portland cement is a carefully manufactured product made from minerals containing lime, silica and alumina as the principal ingredients. The process of manufacture is divided into three stages. The raw materials are first intimately mixed by mechanical means in absolutely correct proportions, and the mixture ground exceedingly fine. The second process is the calcination of the raw materials at a high temperature in order to bring about a perfect chemical combination of the three ingredients. The calcination is carried on to incipient vitrifaction and results in a cement clinker. The third stage in the process of manufacture is the grinding of the clinker to an impalpably fine powder. This powder is Portland cement, and only when the whole of these three processes are employed is the product entitled to be so named.

Artificial Portland cement is a term formerly used to differentiate the scientifically manufactured article as described above from the "natural" cements which are largely produced in Belgium and other countries.

"Natural" cement, often erroneously termed "Natural Portland" cement, is manufactured from mineral deposits which exist in various parts of the world. The deposits contain lime, silica and alumina, the essential ingredients of true Portland cement, but in varying proportions which sometimes do not even approximate those required for the manufacture of a sound product. This deposit is often burned just as quarried, without the intimate mixing and proportioning, failing which a sound and reliable cement cannot be produced.

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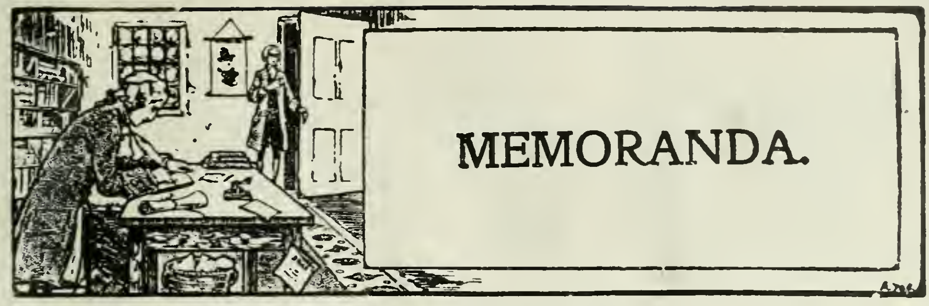

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Removal of Forms in Concrete Work.—*Concrete, U.S.A.*, recommends the following periods as representative of correct practice for the removal of forms in summer weather where Portland cement of normal hardening rate is used :—

Concrete mass work	24–48 hrs.
,, in thin sections	48–60 hrs.
,, columns	48–60 hrs.
,, in beams and girders	12–21 days
,, in long thin slabs	14–21 days

In cold weather the period will be more or less protracted according to the average temperature prevailing, both before and during the setting periods. No attempt should be made to do extensive concrete work with freezing temperatures unless proper provision be made for keeping the concrete from freezing during the setting process.

Repairing Concrete Floors.—*The Engineer* states that an ingenious system of repairing concrete floors which have got out of shape on account of made ground subsiding beneath them has been developed in connection with the extension of the Royal Albert Dock, where a number of large warehouses is being constructed. The floors are of reinforced concrete, and as they are laid short ends of scaffold poles are stood up at intervals of 20 ft. or so. When the concrete is set the poles are withdrawn and leave holes reaching down to the ground. If the floor remains flat the holes are filled in, but if subsidence takes place a portable plant comprising an electrically-driven centrifugal pump capable of giving a delivery pressure of about 20 lb. per square inch is connected with the holes near the hollow and a mixture of ashes and water pumped in. The water escapes by the adjacent holes, the floor is lifted to the proper level, and the foundation solidified.

Aberdeen.—Reinforced concrete culverts, sumps, and pump chamber are being constructed on the north bank of the Dee in order to provide an ample supply of condensing water to the Ferryhill power station of the Corporation.

New Bridge for Paris.—The old Pont de la Tournelle over the Seine, well known to visitors to Paris, is now being demolished, and will be replaced with a two-arch reinforced concrete structure.—*The Engineer.*

Concrete Houses in Italy and France.—Concrete is being used quite extensively in Italy and France in connection with the housing problem. Some of the aggregate in France is procured from the old battlefields. Where sand and gravel are not obtainable broken brick is used as a substitute. At Lens an American Red Cross Hospital is being constructed of poured concrete, broken brick being the aggregate used.

In Italy concrete is being employed for an industrial city for Venetian artisans and their families.

Vancouver Port Development.—Some large works are now in progress for the extension of the dock facilities at Vancouver, B.C. The Canadian Pacific Railway is building a new 1,100 ft. pier, with two-storey sheds and the Vancouver Harbour Commissioners have placed contracts for the construction of a new pier and sheds. The

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latter pier will be 1,200 ft. long by 340 ft. wide, with a shore quay 936 ft. by 350 ft. Reinforced concrete piers will extend along the sides and the outer end, with an embankment of sand and gravel between. At the middle of the pier, where it will be 135 ft. wide, there will be four rows of concrete cylinders carrying transverse concrete trusses to support the floor of the pier. At the outer end of the pier there will be five rows of concrete cylinders, extending the berths into 45 ft. of water. In addition to the sheds there will be on the quay a three-storey reinforced concrete warehouse, 200 ft. long by 82 ft. wide. The total cost of the work is estimated at 6,000,000 dollars, and further developments are under consideration.

Concrete Curb Bridges.—Instead of cutting down the curb to make an entrance to the driveways into private yards, *Concrete, U.S.A.*, says it is quite general in Monrovia, Cal., to build curved concrete bridges over the curb and into the yard.

Dublin University. Lecture on Reinforced Concrete.—The opening meeting of the 27th session of the Dublin University Engineering Students' Society was held in the Engineering School, Trinity College, Dublin, on December 10, when Mr. A. D. Delap, M.Inst.C.E., delivered the inaugural address on "Reinforced Concrete." Professor Alexander, M.A.I., presided, and there was a large attendance of engineers and students.

Mr. Delap, in the course of an interesting address, dealt with the use of concrete in the historic past, and, referring to the specification of materials, explained the reasons why cement and steel lend themselves to use in combination. He went into the reports of the Joint Committee on reinforced concrete, and described the properties of the material as well as the methods used in reinforced concrete work, and the other technical details attaching to its subsequent preparation and solidification. He alluded to the use of reinforced concrete in piles, and said that the most satisfactory method of driving was by a heavy hammer, or, in sand, by water jet. He went on to deal with the methods used in pre-cast work. Generally reinforced concrete was a material of very wide utility, which came into every engineer's practice. Its use was extending every day, and practical methods had advanced very rapidly. In conditions where it was a suitable material it was as nearly permanent as they could hope any of their structures to be, and a knowledge of the principles of construction in this material was an ingredient in the education of every young engineer.

CONCRETE AND HOUSING SCHEMES.

East Ham.—Major Williams, an Inspector of the London Housing Board, recently visited East Ham, and suggested to the Housing Committee of the Borough Council that in view of the shortage of bricklayers, the question of the erection of concrete houses should be considered in connection with the Council's housing schemes. The Committee accordingly recommended that the Borough Engineer be directed to submit a report on the matter, at its next meeting. This report was received, and as a result the Committee has decided to visit the concrete houses in course of erection at Bedford.

Bath.—The Housing Committee of the Bath Town Council is considering the advisability of erecting a considerable proportion of the houses to be constructed under the Council's housing scheme by special methods of construction approved by the Ministry of Health.

Lichfield.—It was reported at a recent meeting of the Lichfield Rural District Council that the question of the erection of 400 concrete houses at Bilston was under consideration, and that a deputation which had visited a concrete housing scheme was very favourably impressed. The Surveyor reported that there was not the slightest doubt that it was an economical system and produced houses very quickly.

Wrexham.—The Wrexham Town Council has authorised a firm of contractors to proceed with the erection of twenty-four *in situ* concrete houses.

Concrete and District Labour.—The Cwmamman (Carmarthen) Urban District Council has decided to proceed with the erection of eighteen houses on the Glanyrafon site. The houses are to be built by direct labour.

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11, VICTORIA ST., LONDON S.W.1

Ministry of Health and Housing.—In their weekly housing report, the Ministry state that for the week ending December 15, 1920, contracts have been placed for 17,722 houses to be built by special methods of construction sanctioned by the Ministry of Health; 4,658 are in course of erection. Under the terms of the Government Grant, 4,170 are being built by special methods, of which 2,530 are in concrete.

There were fifty new housing schemes submitted during the week ended December 11, bringing the total number of schemes submitted to 11,408. Of these 8,736 have been approved and comprise 57,666 houses.

Concrete Sash Weights.—Owing to the high price and difficulty of obtaining cast iron, concrete weights for window-sashes are now being made in the United States. They are reinforced to a wire loop, and are giving every satisfaction.

NEW METHODS AND MATERIALS.

The following materials and new methods of construction have been approved by the Standardisation and Construction Committee :—

Gorse Hall Construction Company, Gorse Hall, Nr. Chorley.—"*P. and T.*" *System.*—A system of concrete block construction with flanges on one end of the blocks which act as bonders and continuous piers in the thickness of the wall for its entire height.

Multee Construction Co., Ltd., 24, Haymarket, London, S.W. 1.—*The* "*Multee*" *System.*—In this system of concrete construction the walls are formed of two pre-cast slabs of standard size, each 2 in. in thickness, a continuous 5 in. cavity being formed throughout the length of walling. Each standard block possesses four stiffeners, this block being divisible into a $\frac{3}{4}$ unit possessing three stiffeners; a $\frac{1}{2}$ unit possessing two stiffeners; and a $\frac{1}{4}$ unit possessing one stiffener. The bonding of these smaller units enables the stiffeners to be in alignment from base to eaves, and also at the angles of the building.

A. Stanley Cox, F.S.I., 16, Queen Victoria Street, Reading.—*Cox's System.*—This system has been designed for the upper storey in connection with the mass production of a standard concrete cottage, no centering or timber being required, and consists of curved hollow concrete slabs 6 in. thick, rebated or grooved on the edges and jointed together with cement, the slabs being supported on T. purlins and finished with a waterproof coating of cement.

John Laing & Son, Dalston Road, Carlisle.—Laing's "Easiform" system of construction is for monolithic concrete and combines shuttering and scaffolding. A double row of shutters is put all round the building and the intervening space filled with concrete 2 ft. high. A second row is then placed on and secured to the first and after this is filled with concrete the first row is removed and refixed, thus forming the third, and so on to the required height.

A. Bomgren, Jnr., 26, Old Burlington Street, London, W. 1.—*The* "*Centa*" *Concrete Blocks* contain three vertical air spaces, are interlocking, and walls of any width can be formed with them. The special feature is that the tops of the blocks are sealed in the process of manufacture, with the result that when laid with mortar between the courses each air space becomes a sealed compartment. The blocks are made in a specially heavy machine, which compresses the concrete to the greatest density.

TENDERS ACCEPTED.

Concrete Houses.

ALCESTER.—The Town Council has accepted the following tenders for the erection of houses in brick or approved methods of concrete construction: 28 houses: Alcester Builders, Ltd., Alcester, £23,996 3*s.*; 10 houses: H. W. Trout, Redditch, £9,094 12*s.* 11*d.*; 122 houses: H. Boot & Sons (London), Ltd., non-parlour type "A.1," £801 12*s.* 9*d.* each; non-parlour type "A.2," £781 7*s.* 6*d.* each ; non-parlour type "A.137," £857 8*s.* 10*d.* each ; parlour type "D," £920 6*s.* 11*d.*

General.

GHENT.—The contract for the construction of two reinforced concrete warehouses for the Municipality of Ghent (recently advertised in this country) has been awarded to Messrs. Van Kerchove & Gilson, of Ghent.

TENDERS INVITED.

SKIPTON.—January 14. For the erection of eighteen houses and road and sewer work, for the T.C. Council Offices, Skipton.

TAUNTON.—January 25. Erection of concrete Bridge over river, for the T.C. Plans, etc., from Borough Engineer.

TORQUAY.—January 14. Erection of seventy-five concrete houses on a system approved by the Ministry of Health, for the T.C.

PERSONAL.

Sir John Francis Cleverton Snell, Member of Council of the Institution of Civil Engineers and Past President of the Institution of Electrical Engineers, has been appointed by an Order of Council dated the 23rd day of November, 1920, to be a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

TRADE NOTES.

Floor and Concrete Stone Surfacing Machines.—Two new surfacing machines have recently been put on the market in Massachusetts. The floor surfacing machine (made in five sizes) is said to surface from 800 to 1,200 ft. of concrete terrazzo floor finished per eight-hour day. The stone surfacing machine is said to be designed to surface either natural or manufactured stone slabs or other pieces up to 12 ft.

Teign Valley Granite Co., Ltd.—Our attention has been called to the concrete products manufactured by the above Company at the Trusham quarries. Concrete blocks of various patterns, concrete fence posts with struts and strainers, flower vases, lintels, sills, etc. are made. The Company have erected many bungalows, houses, shops and other buildings, as well as a little village of forty-eight houses with shops, all from concrete blocks made at their works.

An interesting feature of their activities is the construction of concrete poultry houses in all sizes and designs, which are sent out ready for erection and with full instructions for erection.

The main object in making these structures in concrete is to economise in the use of timber, but of course the further advantage of a more durable structure is gained which will cost little to maintain.

Full particulars of the Company's specialities will be sent on application to the Teign Valley Granite Co., Ltd., Trusham, Chudleigh, Devon.

Portable Air-Compressor.—We have received from Messrs. Millars' Timber & Trading Co., Ltd., a copy of a folder recently issued by them, describing their portable Petrol-driven Air-Compressor. These machines are complete self-contained units, arranged for automatic governing and pressure regulation, and their varied uses, including riveting, caulking, drilling, chipping, pneumatic painting, etc., are fully illustrated.

The use of portable self-contained apparatus saves the losses inseparable from long air pipe lines, and brings within the reach of many users, an economical and convenient service of power.

This folder is obtainable in English, French and Flemish on application.

NEW COMPANIES REGISTERED.

Centrifugal Concrete Blocks and Poles, Ltd. (171056), 7, Lower Belgrave Street, London, S.W., Registered October 27. Manufacturers of reinforced concrete articles. Nominal capital, £50,000 in 50,000 £1 ordinary shares. Directors to be appointed by subscribers. Qualification of directors, £100; remuneration £250 each (Chairman £350).

Zwingler's Damp-proof Walls & Concrete Co., Ltd. (171072), Registered October 27, Stanbridge Road, Leighton Buzzard. Manufacturers of concrete building blocks. Nominal capital, £5,000 in 5,000 £1 shares. Directors: H. R. Phillips, "Wernddu," Bathampton, Bath; F. R. G. Gale, Bridge Farm, Stoke Hammond, Bletchley; and E. Swingler, 6, Albany Road, Leighton Buzzard. Qualification of Directors, £50; remuneration, £50, to be divided.

Northfleet Tile & Concrete Co., Ltd. (171,517). Registered, November 19. 27, Queen Victoria Street, London, E.C. Manufacturers of tiles, concrete, cement, bricks, etc. Nominal capital, £10,000 in 10,000 £1 shares. Directors: F. T. Fisher, W. C. Palmer, W. G. H. Wright and S. A. Bray. Qualification of directors, one share; remuneration to be voted by Company.

John Cobhams, Ltd. (171,664). Registered, November 26. Builders' and Cement Merchants. Nominal capital, £2,500 in 2,500 £1 shares. Directors to be appointed by subscribers; qualification—one share; remuneration to be voted. Subscribers: H. P. J. Rammell, Whitton, Twickenham, and H. W. Wolfe, 5, Denmark Terrace, East Finchley.

RECENT PATENT APPLICATIONS.

141,663.—F. Girlot: Building blocks for hollow walls.
153,102.—T. A. Locan & D. E. Landale: Concrete construction.
153,208.—H. P. Brown: Mixing and placing concrete.
153,417.—K. Yamaguchi: Shuttering for concrete walls.
153,433.—J. Ward: Artificial stone manufacture.
153,491.—C. J. Ross: Concrete building slabs.
153,633.—W. E. Clifton and J. S. Ewart: Concrete building construction.
153,670.—T. Sutcliffe: Moulds for manufacture of building blocks.
153,754.—J. C. Beswarick: Hollow concrete wall construction.
153,829.—P. Lauset: Marline for cleaning cement from planks.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 2. London, February, 1921.

EDITORIAL NOTES.

THE CONCRETE INDUSTRY.

In the concluding portion of his Presidential Address at the Concrete Institute, Mr. E. Fiander Etchells outlined a proposal which had been under the consideration of the Council for the formation of a special class of membership to include such individuals as clerks of works and foremen, it having been felt that less risk would be involved and confidence given to employers if they knew that men of this type, who were members of the Concrete Institute, had had to pass some form of examination which gave them a status in regard to the supervision of reinforced concrete constructional work.

This proposal embodies an idea which has long been in our own mind and which we hope to see materialise.

In view of the enormous development of concrete work during the last few years and the prominent place it now takes in all forms of construction, we are strongly of opinion that the time has come when the industry should be properly organised and a new trade or craft formed—that of the skilled concretor and block-setter. Such a body would in time have its own grades and develop on its own lines as other trades have done.

To all who have been in any way connected with the direction of concrete operations, the need for greater and more systematic education in this class of work has long been obvious. If this new type of mechanic is to come into organised being, his education must not be left to chance; preparation for his advent must be made by a carefully-thought-out scheme of instruction, not only on theoretical, but on practical lines. True, Technical Institutions introduce concrete as part of their engineering courses, but we want to see more than this; we want to see in the curriculum of every Technical School and Institute, both senior and junior, concrete regarded as an independent subject and courses arranged in both theory and practice, for, in order to secure thorough efficiency and intelligent workmanship, the two must go hand in hand.

Such courses as we have in mind would be carried on on modern lines, and would include amongst other methods lantern slides and films in order to add attractiveness to the subject, visits to concrete works, where the students could see the work of concreting in actual operation, visits to exhibitions of concrete products where the wide possibilities of the material would be brought home to them, and, what is of prime importance, regular practice in all the operations necessary for the production of concrete of the first quality, and in various forms of constructional work in concrete both plain and reinforced.

As, however, the principles and methods of handling concrete apply to all kinds of work—the application of it being the function of the architect and engineer, and the moulds, where used, the duty of the carpenter—we do not think that the courses for workmen and apprentices should necessarily be very long. Probably the whole ground could be well covered in a six months' programme; but whether or not this is found possible the courses would certainly not be anything like so lengthy as those of other trades, such as carpenters or plumbers, where instruction has to be given in different kinds of work that the man may be called upon to perform. Instruction for concrete work is a comparatively simple matter, and, in view of its importance in the building trades, this fact should encourage educational authorities to institute the classes we suggest.

If such a scheme could be carried into effect, safeguards would be provided and the foundation laid for thoroughly sound practice in an industry which will, undoubtedly, play a far more prominent part in the future than even it does to-day.

MINISTRY OF HEALTH, STANDARDISATION AND NEW METHODS OF CONSTRUCTION COMMITTEE'; REPORT ON THE FIRST YEAR'S WORK.

It would have been consistent with the popular conception of a Government department, if it had refused to sanction the erection of cottages, to which it was giving financial assistance, in any but the most usual materials. Actually, a very different course was adopted by the Local Government Board (now the Ministry of Health), for in April 1919 a Committee was appointed whose terms of reference were to consider questions of standardisation in regard to materials and structural fittings, and to consider proposals submitted to the Board in regard to new materials and methods of construction in connection with State-aided housing schemes.

From a perusal of the first year's report, which we now have before us, it is evident that the Committee have dealt with the applications which have been submitted to them, largely as a result of invitations which appeared in the press, in great numbers with particular sympathy, and approvals have been given to systems which cover a very wide range.

NEW METHODS AND MATERIALS.

The report states that the majority of these applications were for methods that employed concrete in some of the manifold forms in which it is suitable for the erection of small houses. It would appear that the most frequent faults have been: in block construction, a tendency to make the blocks too heavy and too large for convenient handling, and in reinforced construction an inability to build with sufficient economy to compete commercially with other systems of concrete construction. We are surprised that no mention is made of what seems to us a serious defect in many of the patent systems that we have examined, and that is their lack of flexibility, their tendency to dictate the very form that the house shall take.

The Committee view with particular favour monolithic concrete construction, and they consider that where suitable aggregate is obtainable on or near the site this method should prove more economical and more expeditious than block or slab construction, which involves more handling and more time in manufacture and seasoning. Where blocks are used, the hollow wall constructed in two thicknesses and connected with wall ties is recommended in preference to the cavity block.

The report includes an interesting section which deals with rammed materials. While not wishing to disparage any attempt that may be made to expedite the production of houses, we cannot but feel that, for the most part, these efforts to revive methods of construction that have, in course of time, been superseded by others of greater efficiency are not likely to yield results sufficiently satisfactory to justify the inevitable risk that must accompany such attempts. Except in certain outlying districts, which still remain almost untouched by modern developments, the tradition for building in these methods has almost perished. Where, however, the tradition still exists it may be worth while preserving it. A certain saving should certainly be effected by the use of unfired materials.

THE CONCRETE BLOCK.

Under the heading of "Building Appliances" the Committee express an opinion on a matter that has always been somewhat contentious. They consider that the manufacture of blocks by a properly designed pressure machine is more satisfactory than hand tamping. Both systems have their adherents. No opinion, however, is expressed as to the relative merits of wet and semi-dry manufacture. The tendency to-day is certainly for the machine to supersede the mould; the increase in output is sufficient to account for this, and probably the only disadvantage which the machine may have over wet mixing, is the risk which accrues from the failure to apply sufficient moisture during seasoning. It is surprising that although the report favours monolithic construction, so little attention is devoted to shuttering, for the success of this method depends upon the efficiency and cheapness of the system of shuttering. It must be capable of frequent re-use and yet be adaptable to any plan, it must be light, easy to erect, and easy to keep clean. It must be rigid.

STANDARDISATION OF FITTINGS.

The work which was performed by the Committee in standardising fittings has proved extremely useful. Baths, lavatory basins, water-closets, sinks, gutters, rain-water pipes, and many other structural fittings were reported upon to the Director-General of Housing, and the necessary instructions for the manufacture of the standardised goods issued through the D.B.M.S. In determining upon the sizes and shapes of the goods, the question of facilitating transport and economising space by "nesting" was considered in connection with such articles as baths and gutters, likewise the cost of fixing and of maintenance.

The report contains several interesting appendices, including a report to the Board of Agriculture made in 1797 on pisé construction, and a report translated from the French on rammed clinker and lime. The Ministry of Health's specifications for concrete construction and a complete illustrated list of the systems of house construction approved up to April 1920 are also included. The report, which is obtainable at 1*s.* 6*d.* from H.M. Stationery Office, is certainly an eloquent testimony to the development that has occurred during the last eighteen months in the use of concrete.

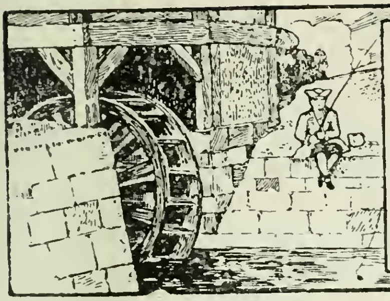
FAILURE OF A CONCRETE FLOOR.

The judgment recently delivered in the Scottish Law Courts by Lord Sands, in which he awarded £1,500 damages and half costs against a firm of contractors for the failure of a concrete floor which they had erected, again emphasises the absolute necessity of sound construction, both theoretical and practical, in all concrete work. The floor in question, which was designed to carry a load of 2 cwt. per square foot, was built towards the end of 1916, and in April 1918 it was found to have failed. As reported, Lord Sands summarised the constructional faults as follows :—" Columbian bars at 2 ft. centres were a very weak form of reinforcement ; the concrete was of the poorest description of concrete used, and was not of high quality of its own description ; and the reinforcement bars were not cranked up over the joists where the tension was greatest on the top. He could not find evidence of the success of a single floor with Columbian bars and cinder aggregate concrete in such a workshop." We know nothing of this particular case other than what has been contained in several newspaper reports, but if the above statement accurately sums up the causes of the failure nothing but failure could have been expected, and had the floor been constructed of any other material on equally unsound lines, failure would also have been certain.

Cases of failure in concrete work are so rare that when they do occur they receive wide publicity, to the detriment of the interests of the industry as a whole. This is particularly to be regretted, for if concrete work is properly designed in the first place, and carried out correctly under competent supervision, there is no reason whatever why failures should occur at all.

GENERAL NOTE.

Concrete Roads.—We desire to call the attention of our readers to the book on "Concrete Roads" which has now been published, and can be obtained from the Publishers, Messrs. Concrete Publications, Limited, at 4, Catherine Street, Aldwych, W.C.2. (*Price 8s. 6d. post free.*)



REINFORCED CONCRETE WORK AT THE COLCHESTER GAS COMPANY.

The following is a short description of some of the reinforced concrete work carried out for the Colchester Gas Company, under the supervision and in accordance with the general plans of Mr. W. W. Townsend, Engineer of the Company.

The working drawings for both Retort House and Bunkers were prepared by Messrs. Edmond Coignet, Ltd.

FOUNDATIONS FOR RETORT HOUSE AND RETORTS.

Owing to the inconsistent nature of the ground it was found necessary to provide for reinforced concrete piles and foundations, to support the heavy brickwork of the retorts and also the concentrated loads from the steel stanchions of the building.

The level of the ground on the site was 4 ft. 4 in. below the yard level, and the engineer decided to take the yard level as the top of the foundation work in preference to building up from the lower level, thereby reducing the length of the heavy steel stanchions and the amount of brickwork required in walls and retort bench. This plan enabled the foundation work to be carried out without any excavation except where piles had to be lengthened, and it allowed for the designing of the concrete walls, capping the piles as beams distributing the loads on the piles. Under the retort bench a floor was provided, strongly reinforced, in order to carry the heavy weight of the retort bench between the beams capping the piles.

The whole structure, including the brick walls of the building, is entirely supported upon the piles. The retort foundations measure about 67 ft. long by about 30 ft. 9 in. and include 42 piles. The foundations of the building, the dimensions of which are approximately 84 ft. by 64 ft., measured from the centre of the walls, contain 28 piles. All the piles were made to a standard length of 23 ft. and octagonal in section with a diameter of 16 in.

The piles were of the usual Coignet type, namely, with a certain number of vertical bars of small diameter, tied together by means of hoops, the end of the pile being fitted with a cast-iron shoe. These piles were driven by means of a 2-ton monkey worked by a steam winch, mounted on the pile frame which was moved in various positions on rails, in accordance with the requirements.

The piles were reinforced in accordance with the various loads which they had to carry and which are as follows :—

Piles No. 1 were constructed to carry 40 tons.

Piles No. 2 were constructed to carry 60 tons.

Piles No. 1 were originally intended to be 12 in. octagonal instead of 16 in.,

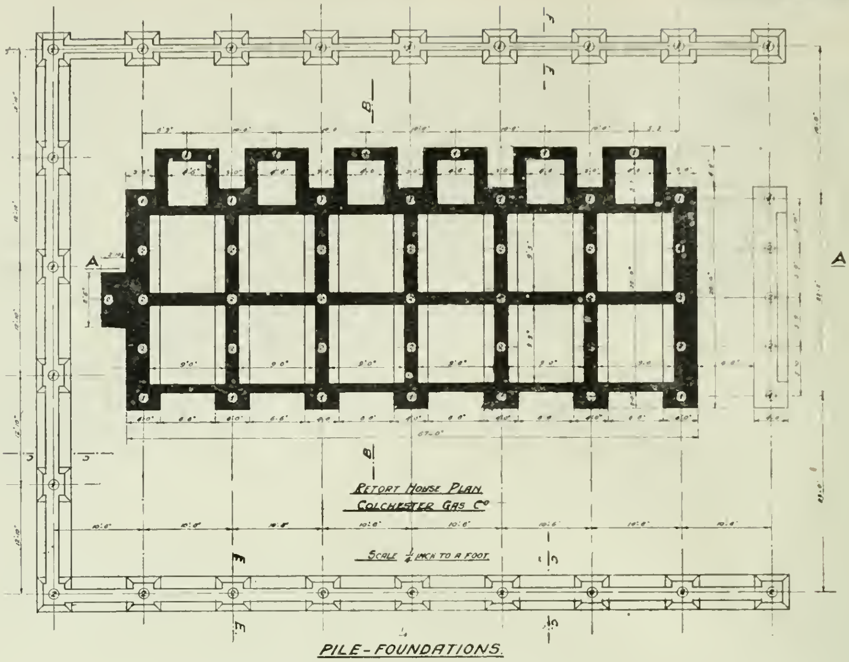


Fig. 1. Pile Foundations for Retort House.
Reinforced Concrete Work at the Colchester Gas Company.

but the extra quantity of concrete required to make all the piles of the same section was small, and it was decided to use the same moulds throughout.

After the piles were driven to the required set, it was found that owing

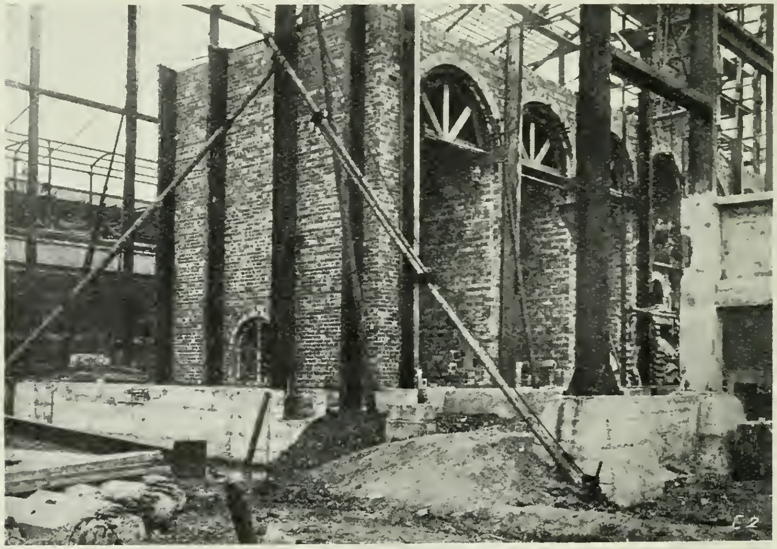


Fig. 2. Retort House.
Reinforced Concrete Work at the Colchester Gas Company.

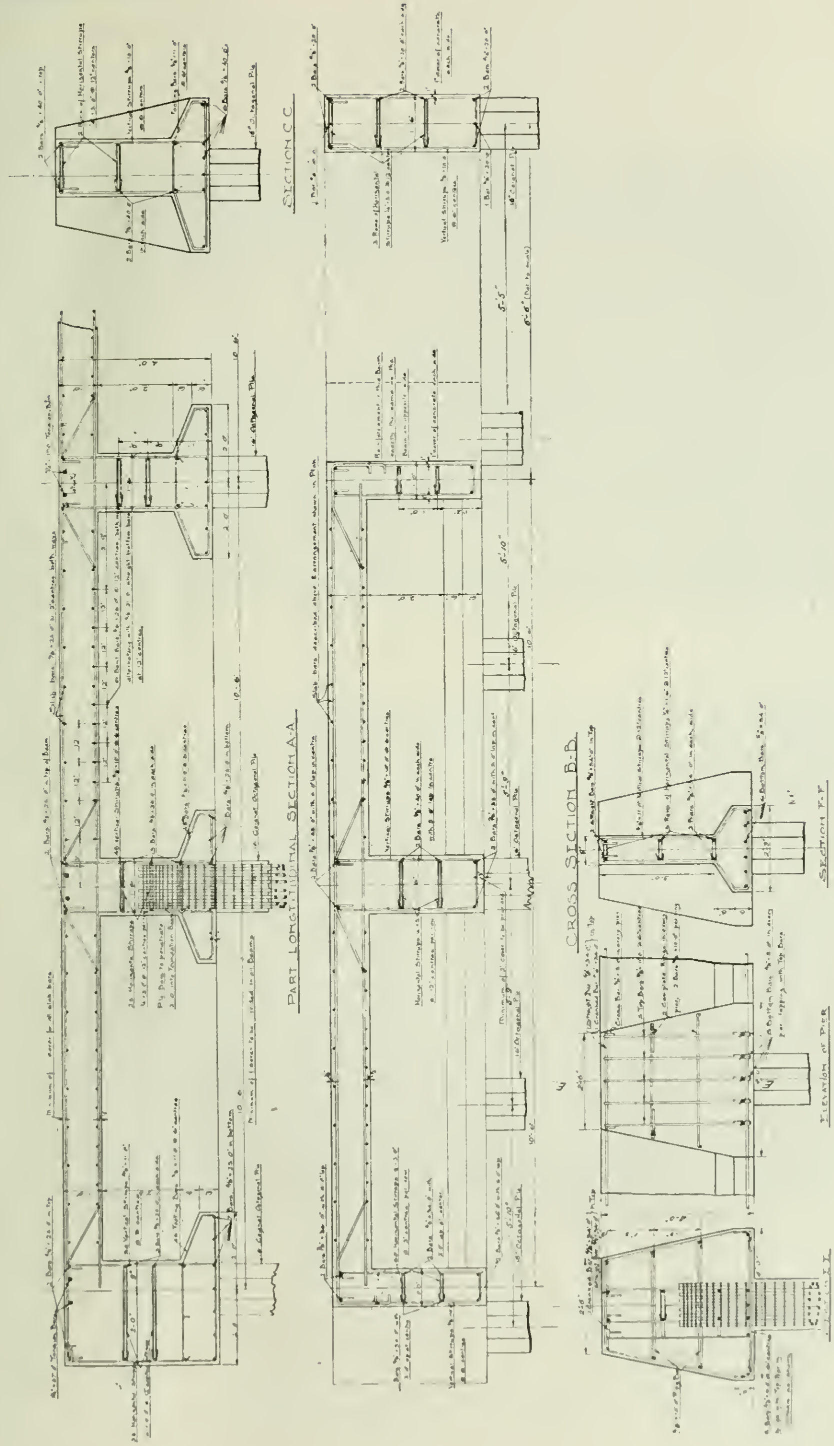


Fig. 3. Retort House Foundations.
Reinforced Concrete Work at the Colchester Gas Company.

to the variable nature of the substratum, some of the piles went down several feet more than others. In this case the heads of the piles were stripped and the top portion was lengthened in situ in order to form a proper junction for the reinforced concrete foundation beams.

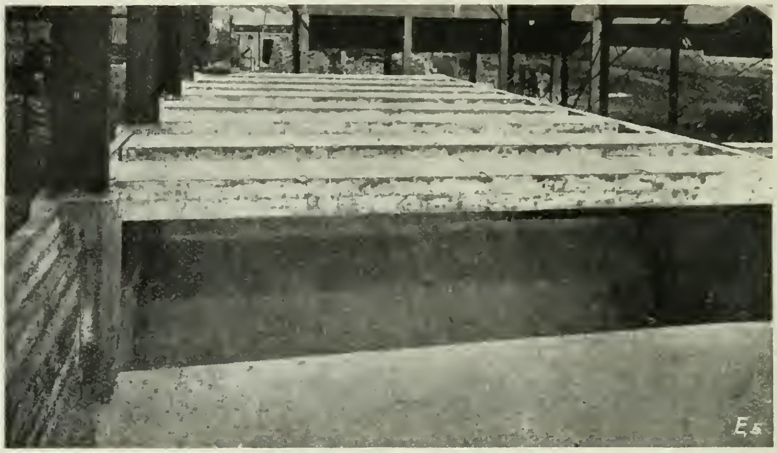


Fig. 4. Showing Pre-cast Beams in Position.
Reinforced Concrete Work at the Colchester Gas Company.

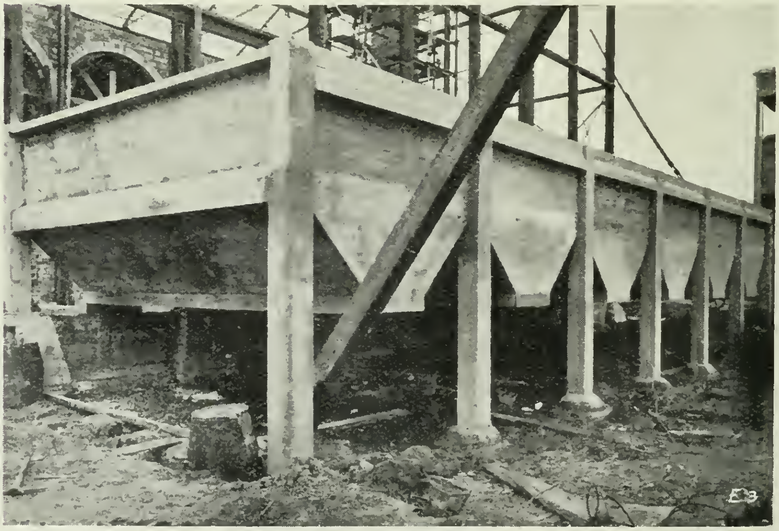


Fig. 5. The Finished Bunker.
Reinforced Concrete Work at the Colchester Gas Company.

In order to give greater stability to the foundations supporting the stanchions and brick walls of the building, the reinforced concrete beams were provided with a footing 4 ft. wide.

The whole of the reinforcement of the beams and slabs was composed of round bars of mild steel. Owing to the considerable loads coming upon the

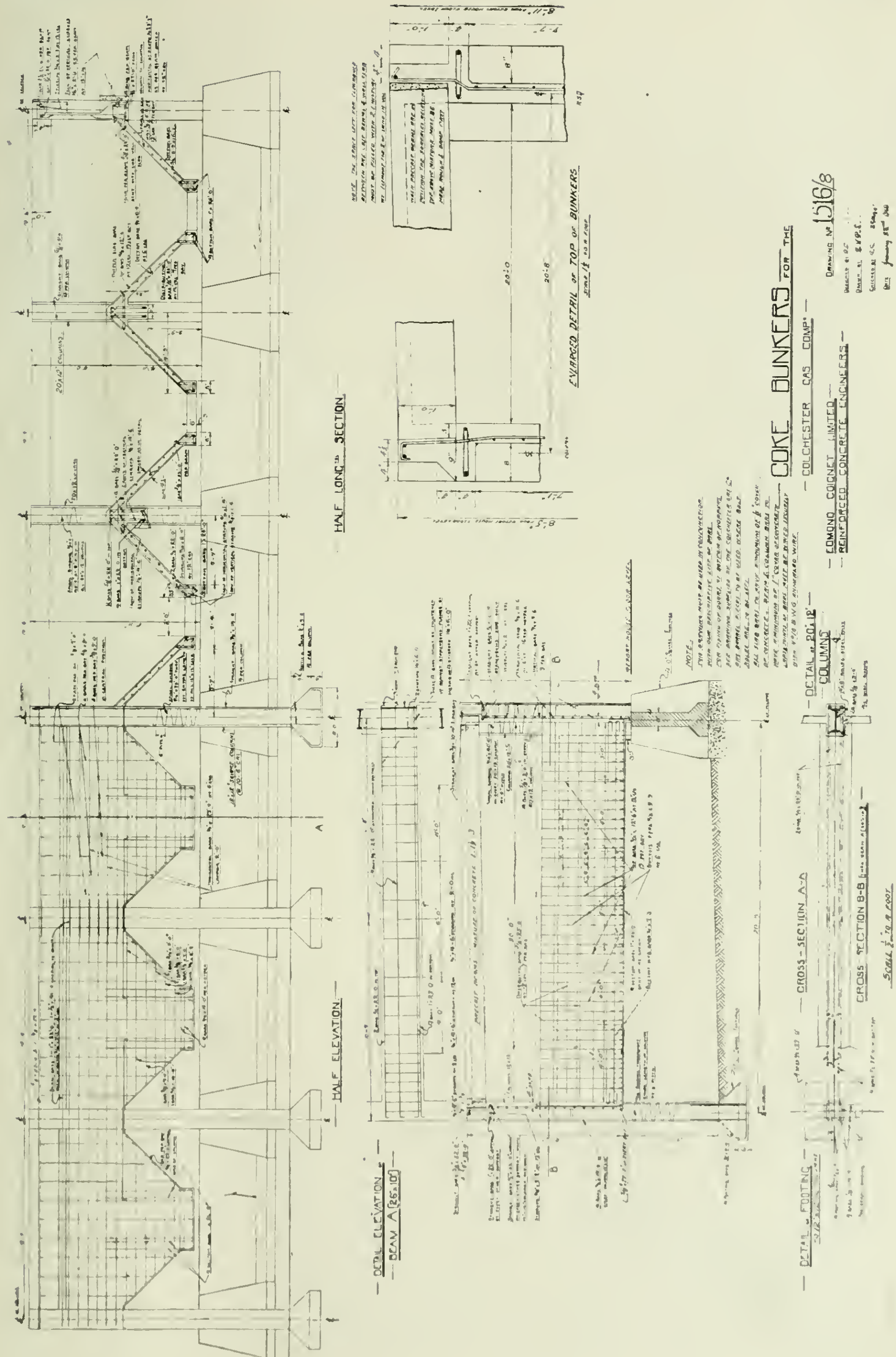


Fig. 6. General Details of the Coke Bunkers.

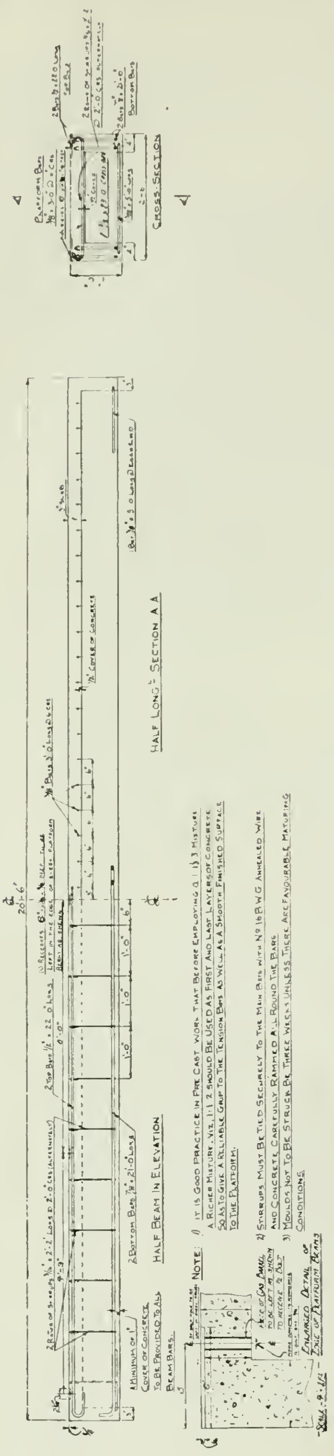

CROSS-SECTION
HALF LONG^L SECTION A A
HALF BEAM IN ELEVATION
20'-6"
A MINIMUM OF 1" COVER OF CONCRETE TO BE PROVIDED TO ALL BEAM BARS.
ENLARGED DETAIL OF EDGE OF PLATFORM BEAMS
NOTE: 1) IT IS GOOD PRACTICE IN PRE-CAST WORK THAT BEFORE EMPLOYING A 1:1½:3 MIXTURE A RICHER MIXTURE, VIZ. 1:1:2 SHOULD BE USED AS FIRST AND LAST LAYERS OF CONCRETE SO AS TO GIVE A RELIABLE GRIP TO THE TENSION BARS AS WELL AS A SMOOTH FINISHED SURFACE TO THE PLATFORM.
2) STIRRUPS MUST BE TIED SECURELY TO THE MAIN BARS WITH Nº 16 B.W.G. ANNEALED WIRE AND CONCRETE CAREFULLY RAMMED ALL ROUND THE BARS.
3) MOULDS NOT TO BE STRUCK BE THREE WEEKS UNLESS THERE ARE FAVOURABLE MATURING CONDITIONS.

Fig. 7. Details of Pre-cast Platform Beams for Bunkers.
Reinforced Concrete Work at the Colchester Gas Company.

slabs of the retort foundations, it was necessary to provide a meshwork of bars to take up the compression.

The bars of the beams were linked together by means of the usual type of stirrup.

The work was carried out by Messrs. Walter Jones & Sons, of Westminster.

COKE BUNKERS.

A row of coke bunkers also designed on the Coignet system was erected alongside of the retort house.

The general dimensions of these low level bunkers are 66 ft. in length by 20 ft. 8 in. in width, measured from the centres of the columns, the total height being 13 ft. 2 in. above the level of the ground.

The object of these bunkers is for the storage of the coke coming from the retorts, and they are capable of containing approximately 500 tons of coke.

An interesting feature of this work is due to the fact that all the beams on the top of the bunkers were pre-cast and placed in position by means of a crane. The advantage of this method of procedure was that no centering or scaffolding was required for the making of these beams, which were all moulded on the ground in a very economical manner. These pre-cast beams measured 1 ft. in height by 2 ft. 6 in., and they were composed of two small longitudinal beams 12 in. by 4 in., supporting a slab 3 in. thick. The object of these platforms is to carry the rolling load of coke wagons weighing about one ton each including the load of coke.

The whole of the reinforcement in the bunkers was composed of round bars of mild steel and the reinforced concrete pillars were supported by means of piles. Each hopper is fitted with two openings for the discharging of the coke into the trucks.

The work was carried out by Messrs. Peter Lind & Co., of Westminster.

SHEARING STRESSES IN RECTANGULAR REINFORCED CONCRETE BEAMS.

By ALFRED FYSON, M.Inst.C.E.

(*Concluded.*)

The first part of this article appeared in our January issue, page 14. While we have much pleasure in publishing the following thoughtful and original article, it must not be supposed that we are in agreement with the conclusion arrived at, and, in point of fact, we publish in this issue some comments on some of the points raised in Mr. Fyson's article.—ED.

Diagonal Tension, etc.—Thus far in these investigations there have been given the intensities of the internal direct horizontal stresses at a certain section, and the means of determining the internal tangential stress intensities at any point in that section; as both kinds of stresses are distributed over the material at the given point simultaneously, it is necessary to find the resultant effects due to their combined action, and those resultant effects may be deduced as follows :—

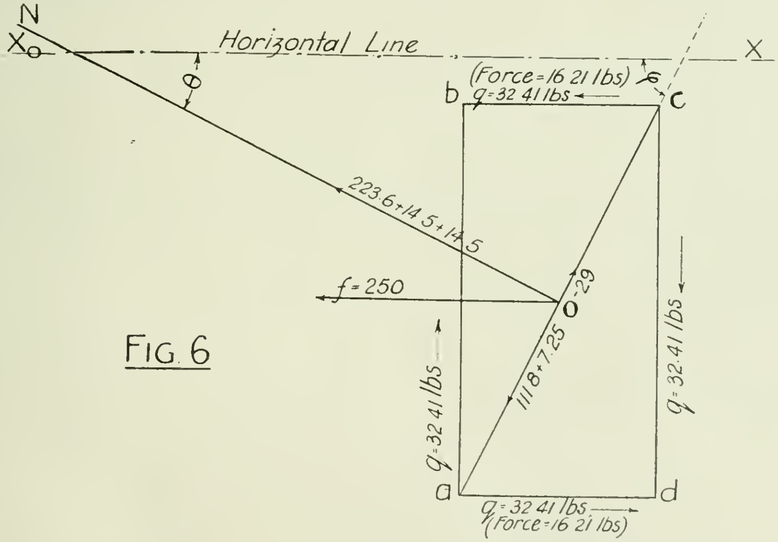


FIG. 6

In *Fig.* 6 consider *ac* as a side of an oblique plane, suppose it drawn at any desired inclination through some point in the depth aa_0 of the beam at which it is required to find the resultants of the stresses known to be acting there, and let that point be represented by the small rectangle *Fig.* 5 near to where aa_0 is cut by the plane *ee'*; let *ac*, *Fig.* 6, be bisected at *O* and *ON* be drawn normal to it making an angle θ with the horizontal line X_0X, *ac* itself having the inclination with the horizon. About *ac* as a diagonal let the rectangle *abcd* be constructed, that rectangle is supposed to be the small element in the depth of the beam against and through which stresses already calculated are acting, and its diagonal *ac* represents a side of the plane on which the resultants of the combined known stresses are required; with the undefined inclination of *ac* as drawn in the figure it is found that the length *ad* is equal to one-half *ab*.

Each known stress acting on the element *abcd* is to be resolved into forces or stresses through the lines *ON* and *ac*, the former denoting direct and the latter shearing stresses. The depth *ab* of the element is supposed to be unity, or say 1 inch, and its breadth also 1 inch; the stress intensities, which are at lb. per square inch, may be supposed to be forces acting normal to the face *ab* and along the faces *ab*, *cb*.

The known forces or stresses at the intersection of aa_0 and ee', *Fig.* 5, are as follow:—

$$\left.\begin{array}{lll} f=250 \text{ lb. acting at right angles to } ab & \ldots\ldots & \text{vide } (\textit{Fig. } 6) \\ q=32\cdot41 \text{ lb. acting along the line } ab & \ldots\ldots \quad ,, & (7\text{A}) \\ q\div2=16\cdot21 \text{ lb. acting along the line } cb & \ldots\ldots \quad ,, & (\text{vii}) \end{array}\right\} \quad (8)$$

The explanation of the term $q\div2=16\cdot21$ lb. in (8) stated briefly is this:—Static equilibrium demands that the opposite moments due to the two pairs of tangential couples shall balance. Therefore, in the element *abcd*, *Fig.* 6, as *cb*=one-half *ab* then the tangential force along *cb* equals half that acting along *ab*, the intensity *q* being the same on each face of the rectangle.

The force acting along *cb* is then:

$$q\times\frac{cb}{ab}=\frac{q}{2}=\frac{32\cdot41}{2}=16\cdot21 \text{ lb.} \quad \ldots\ldots\ldots\ldots \quad (\text{vii})$$

The simple work of decomposing each of the forces in (8) into components through *ON* and along *ac* will not be detailed here, but only the results, and they are to be found in (*viii*), following the order as given in (8):

$$\left.\begin{array}{l} \text{Forces normal to } ac \text{ through } ON=223\cdot60+14\cdot50+14\cdot50=252\cdot60 \text{ lb.} \\ \text{Shearing forces along the line } ac \quad =111\cdot80-29\cdot00+\ 7\cdot25=\ 90\cdot05 \text{ lb.} \end{array}\right\} \quad (viii)$$

The negative sign in (*viii*) shows the shearing force to be acting in a direction contrary to that of each of the other items along the line *ac*. As the total results in (*viii*) are supposed to be acting on the oblique plane represented by *ac* they must be divided by that length in order to reduce them to the same uniform intensity of stress as that already used, that length is:

$$ac=\sqrt{ab^2+bc^2}=\sqrt{1+(\tfrac{1}{2})^2}=1\cdot118 \quad \ldots\ldots\ldots \quad (ix)$$

The total intensity of stress normal to *ac* acting along *ON* and the total shearing intensity of stress acting along *ac* are then found as follows:—

Let *p* be the normal stress acting on *ac* at lb. per square inch;

Let *u* be the shearing stress acting along *ac* at lb. per square inch;

Then from (*viii*) and (*ix*) the intensities of stresses are:

$$\left.\begin{array}{l} p=252\cdot60\div1\cdot118=225\cdot94 \text{ lb. per sq. inch} \\ u=\ 90\cdot05\div1\cdot118=\ 80\cdot55 \text{ lb. per sq. inch} \end{array}\right\} \quad \ldots\ldots \quad (x)$$

Any other point in the depth of the beam may be treated in a similar manner and the stresses *p* and *u* found on any oblique plane traversing that point when the values for *f* and *q* acting on it are known.

By many writers on reinforced concrete, when *p* is a "pull," the stress derived is generally known as "diagonal tension."

The "Greatest Principal Stress" and its "Axis."—In *Fig.* 6 the inclination given to *ac* is supposed to be at "hap-hazard," and is quite undefined in a general sense, therefore it is a variable, and can have as many different angular positions given to it as may be desired, each different inclination producing different values of *p* and *u*—the stress intensities *f* and *q* remaining constant.

There must, then, be some angle θ of inclination ON which will cause p to be a maximum, and there must be some angle φ of inclination ac which will cause u to be a maximum; those maxima results could be found approximately by a system of "trial and error" on various inclinations—as just shown in (x)—until the required maxima were found to some close degree of accuracy. There are, however, certain well-known formulæ which can be used so as to obviate such approximations, and they will now be given. The intensity of the stress p on an oblique plane through any desired point is a maximum p_m, when the resultant of all the forces acting on and through that plane is wholly normal to it; then also the shearing stress along that plane becomes null. The inclination θ of the normal to the plane with the horizon, due to the maximum normal intensity of stress p_m, and the corresponding value of p_m, are found as follows:—

The angle θ for p_m . . . . $\tan 2\theta=\frac{2q}{f}$ . . . . (9)

The maximum intensity of stress . $p_m=\frac{f}{2}+\sqrt{\left(\frac{f}{2}\right)^2+q^2}$ . . . . (10)

$$\left.\begin{array}{lll} \text{At the neutral axis where } f=0 \ldots & p_m=q \text{ and } & \theta=45^\circ \\ \text{At the extreme surface where } q=0 \ldots & p_m=f \quad ,, & \theta=0^\circ \end{array}\right\} \quad (xi)$$

The above equations are for tension, but by changing f into f_o they can become applicable for compression.

The quantity p_m as given in (10) is in statics called a "greatest principal stress," and its direction of action as given in (9) is called a "principal axis of stress." There are innumerable "greatest principal stresses" throughout the length and depth of a beam, and any of them can be found by equation (10) when f and q are known at the required points.

Besides the "greatest principal" there are in beams the "least principal stresses." As their name suggests, they are of less importance than the former, and need not be dealt with herein, but cases occur in constructions of various kinds in which they have to be reckoned with.

The Maximum Shearing Stress on an Oblique Plane.—The formulæ for finding the maximum shearing stress intensity u_m on an oblique plane, and the angle of inclination φ of that plane with the horizon, are as follows:—

In *Fig.* 6 let ac represent the plane and φ its angle of inclination—this without having any reference to the known inclination of ac as there drawn in the diagram—

The angle φ for u_m . . . . . . $\tan 2\varphi=\frac{f}{2q}$ . . . . (11)

The maximum intensity of stress $u_m=\sqrt{\left(\frac{f}{2}\right)^2+q^2}$ . . . . . (12)

$$\left.\begin{array}{lll} \text{At the neutral axis where } f=0 \ldots & u_m=q \text{ and } & \varphi=0^\circ \text{ and } 90^\circ \\ \text{At the extreme surface where } q=0 \ldots & u_m=\frac{f}{2} \quad ,, & \varphi=45^\circ \end{array}\right\} \quad (xii)$$

The above equations are for tension, but by changing f into f_o they can become applicable for compression.

Practical Application of the Formulæ (9) to (12).—Proceeding now with the examination of the actual beam already under consideration, three points in the depth of its "tension" part—aO, *Fig.* 5—will be selected for stress analyses, viz.:—

(A) At the bottom of the beam, where the concrete in tension is highly strained.

(*B*) At about 2 inches above the bottom, just over the reinforcement, where the horizontal and shearing stresses are both considerable.

(*C*) At about 2 inches below the neutral axis, where the " diagonal tension " may be equal to or greater than the ultimate stress of the plain concrete.

At (*A*) . . . Here f is found to be 295 lb. per sq. inch, and $q = 0$.

Tension { By equation (9) . $\tan 2\theta = 0 \div 295 = 0$, whence $2\theta = 0$ and $\theta = 0$ . .
,, ,, (10) . $p_m = \frac{295}{2} + \sqrt{\left(\frac{295}{2}\right)^2 + 0} = f = 295$ lb. per sq. in. } (*xiii*)

Shearing { ,, ,, (11) . $\tan 2\varphi = 295 \div 0 = \infty$, whence $2\varphi = 90°$ and $\varphi = 45°$
,, ,, (12) . $u_m = \sqrt{\left(\frac{295}{2}\right)^2 + 0} = \frac{f}{2} = 147{\cdot}50$ lb. per sq. in. } (*xiv*)

At (*B*) . . . Here f is found to be 250 and q (by equation 7A) is 32·41 lb. per sq. inch. Worked out by equations (9) to (12) as in (*xiii*) and (*xiv*) the results are :—

For tension $\theta = 7° \, 16'$ . . . $p_m = 254{\cdot}13$ lb. per sq. in. . . . (*xv*)
For shearing $\varphi = 37° \, 44'$ . . $u_m = 129{\cdot}13$,, ,, ,, ,, . . . (*xvi*)

At (*C*) . . . Here f is found to be 180 and q is found to be 30 lb. per sq. in. Worked out by equations (9) to (12) as in (*xiii*) and (*xiv*) the results are :—

For tension $\theta = 9° \, 13'$. . . $p_m = 184{\cdot}86$ lb. per sq. in. . . . (*xvii*)
For shearing $\varphi = 35° \, 47'$ . . . $u_m = 94{\cdot}86$,, ,, ,, ,, . . . (*xviii*)

With respect to the stress of 184·86 lb. per sq. in.—the diagonal " tension " at (*C*)—it is practically equal to the ultimate stress of the plain concrete intension. That ultimate stress, taken to be about 185 lb. per sq. in., has been deduced for present purposes from the breaking strength of a plain concrete beam carried out by Dr. Faber at the same time as he experimented on the beam utilized in these investigations and described in *Fig.* 4.

Adhesion of the Concrete to the Reinforcement.—The horizontal shear at the reinforcement is found by multiplying the " stress due to reinforcement " in (*vi*) by *B* the breadth of the beam.

Thus the stress per inch run of reinforcement $= 11{\cdot}36 \times 8 = 90{\cdot}88$ lb. . (*xix*)

The rods being two in number, and the diameter " d " of each being $\frac{3}{4}$ in., then on the surface of each rod—

The adhesion intensity $= 90{\cdot}88 \div 2\,\pi\, d = 19{\cdot}29$ lb. per sq. in. . . . (*xx*)

The foregoing equation (*xx*) gives the mean stress, the maximum at some part of each surface is no doubt considerably greater, but whatever it is, it seems probable that in a rectangular beam under ordinary conditions the ultimate adhesive stress would never be reached so long as the beam remained unruptured.

Summary of Stresses at the First Rupture.—Collecting the values of the various kinds of stresses given by equations (*xiii*) to (*xx*) acting at the section $a\,a_0$, *Fig.* 5, and to one or more of which the first rupture of the beam was due, the main results are given in (13) as follow :—

Greatest direct horizontal stress in tension . .	$f = 295$ lb. per sq. in.	by (3)	(13)
" Diagonal tension " just above the reinforcement.	$p_m = 254{\cdot}13$,, ,, ,,	,, (*xv*)	
,, ,, 2 ins. below the neutral axis .	$p_m = 184{\cdot}86$,, ,, ,,	,, (*xvii*)	
Greatest tangential stress	$q = 32{\cdot}41$,, ,, ,,	,, (7A)	
,, shearing stress on an oblique plane . .	$u_m = 147{\cdot}50$,, ,, ,,	,, (*xiv*)	
,, horizontal shear on each rod (90·88 ÷ 2).	$= 45{\cdot}44$ lb. per lin. ,,	,, (*xix*)	
,, " adhesion " stress	$= 19{\cdot}29$,, ,, sq. ,,	,, (*xx*)	

An inspection of the items given above in (13) shows that with the exception of the first three, each stress is well within its ultimate limit ; and of the first three only the first and third need consideration. The first rupture, therefore, was due to a direct stress on the concrete of 295 lb. per sq. in., or to a diagonal tension of nearly 185 lb. per sq. in. This apparent anomaly, that a less stress might produce rupture sooner than a greater, is due to their relative positions, for it is to be remembered that concrete when " protected " by the reinforcement always exhibits greater strain than in its plain state. In the present instance the material 2 ins. below the neutral axis is no doubt sufficiently near to the reinforcement to be influenced to some extent by its " protection," and would therefore be able to withstand a stress of more than 185 lb. per sq. in. without rupture. In deeper beams, however, the ameliorating influence of the reinforcement, in similar relative positions, would diminish as the depth became increased. The first rupture in the beam was therefore due to the horizontal direct tensile stress at the bottom of the concrete of 295 lb. per sq. in. ; and such stress, as an ultimate limit, appears to be fairly consistent with stresses deduced from many examples of beams of a similar character.

So far as stresses due to direct shear are concerned they appear to be of comparatively small intensity, and in ordinary rectangular beams the first rupture is probably never due to shear itself nor to the slipping of the concrete on the rods. The ultimate strength of concrete in shear appears to be difficult to obtain by experiment, for authorities do not agree, even approximately, as to the limits to be assigned to that strength. But if the results of theory, as given by equation (12), are to be relied on for practical purposes, it would appear that the strength of concrete in shear would not be less than half its ultimate strength in compression. At or near to the neutral axis, however, the limit of the ultimate shearing stress intensity cannot be put higher than that of the ultimate tensile stress limit allowed for the concrete in its plain state, for there $p_m = q$ and p_m cannot be greater than the ultimate limit of f as supposed in its plain state.

In the foregoing investigations certain stresses have been employed for the calculation of the moment of resistance of the beam (vide *Fig.* 5) ; they include the value of the concrete in tension, and are believed to be fairly in accord with actual results at the first ascertained rupture. It is not, however, of so great importance to know that those represent the true actual stresses as it is to know that some such similar stresses are always to be found and do really exist in all cases of flexure ; for with such knowledge the accepted theoretical principles which govern the determination of the shearing stresses can be employed so as to produce reliable and rational results ; without such knowledge any reliable or rational determination of those shearing stresses is rendered perfectly hopeless and impossible.

As the means for finding the weak and critical points in the depth of a beam, due to shearing stresses, have now been given at some length, it may not be out of place to offer a few remarks as to the means usually employed, and those which might possibly be employed, for strengthening and overcoming those weak and critical points.

Web-Reinforcements, Stirrups, Inclined Bars, etc.—The capability of a reinforced concrete beam to remain unruptured during flexure is dependent not only on the power of the concrete to remain intact whilst resisting the horizontal tensile stresses, but also on its power to remain intact whilst resisting the effects of " diagonal tension," or that combination of horizontal tensile and oblique shearing stresses existing in the concrete between the reinforcement and the neutral axis. In order to resist the effects of " diagonal tension " various auxiliaries are adapted to the reinforcing bars and they take the form of vertical, inclined and curved bars and rods called " stirrups," the ends of the main bars themselves being often " hooked " or bent up ; any such arrangement is generally known as " web-reinforcement."

There are numerous forms of " web-reinforcements," each different arrangement being designated a " system." Some of the " systems " are fairly simple in appearance and application, and some of them very complex in both. There are perhaps nearly as many different " systems " as there are different forms into which the metal can be bent, and for each " system " there appears to be some claim to superiority over any other. Seeing that the duty of a beam is generally of a simple nature—merely to support with due safety a vertical, and often stationary, load of known weight—it seems rather surprising that some form of web-reinforcement has not been evolved which would definitely prove its superiority both as regards theory and practice. It is certainly one of those instances in construction where it is desirable that theory and practice should be fairly in harmony, but at present no well-defined theory has yet been advanced which has obtained general acceptance, and as regards practice there exists a " commercial " side to it which will be difficult to overcome until rational theory has proved and established itself. Failing the assistance of theoretical guidance, the stresses and strains on the various pieces constituting a system of web-reinforcement are not amenable to rigorous mathematical treatment; recourse is therefore had to the results of experimental data. From those much information is gleaned as to what is happening when a beam is well ruptured or at the point of complete destruction. Unfortunately, but little is to be gleaned from those data as to what is happening just before ruptures commence—a very important period—or when the beam is carrying its maximum safe load. Stresses on the pieces at the " safe load " evolved from those as empirically deduced from the breaking down load can only be considered as intelligent conjectures, for the ultimate load on a beam of any material is always found to be an erroneous criterion on which to base stresses induced by inferior loads. Some of the systems of web-reinforcement show, in tests, very high load-carrying power over that of others, when a beam is carried to total destruction ; but it must not be inferred from this that the moment of resistance of a beam which determines its "safe" load can be in any degree increased by their employment. Such " safe " load for any " system " is limited by the area of the reinforcement, the permissible stress allowed on the metal, and the quality of the concrete ; and the duty of all " systems " is to prevent rupture of the interior part of the concrete to an extent at least equal to that afforded by the reinforcement at the exterior part. Looking to the fact that in the design of a beam, sufficiency of strength for safety and uniformity of strength for economy ought to be kept in view, it seems preferable to employ some simple " system " which will provide a fair margin of safety for the working load, rather than some more complex, and probably costly, system which can be made to show higher results at the load causing total destruction.

In some cases a beam, near to its supports, seems to develop a certain degree of weakness—perhaps chiefly due to friction at the bearings causing concentration of stresses—and this it is sought to relieve by bending up the ends of the reinforcing bars at some little distance from the bearings, up to and over which they are carried. This " bending up " of the ends of the bars may sometimes give the desired result, but unless it is carefully and judiciously effected it might tend to increase the evil it was supposed to remedy.

The use of vertical stirrups attached to the reinforcement as means of providing against the effects of " diagonal tension " is often employed. They are however incapable of resisting any horizontal strain—except as mere studs; they can only transmit vertical strain and that only in a vertical direction, and they cannot act independently of the concrete surrounding them so long as the beam remains a compact and unruptured mass. Experiments carried just beyond the first small ruptures in the concrete do not appear to show any particular advantage in the use of such stirrups, but towards and up to the total destruction of a beam they do appear to be elements which tend to increase the ultimate load. As a beam appears to break down less suddenly when furnished with stirrups than without them, they may be looked on as extra factors of safety.

Inclined and curved stirrups would seem to be more in accord with some of the requirements of theory than vertical ones. Although they suffer from nearly the same disabilities, experimental tests appear to show them to be somewhat more effective, but not to any great extent. They are supposed to transmit some of the internal shearing stresses to the reinforcement, but that does not seem to be theoretically possible whilst the concrete remains intact. Their actual value is probably due to the binding effect they produce on the concrete itself surrounding them; but the too upright inclination and too great distance apart at which they are usually set would no doubt tend to prevent a maximum efficiency.

Professor F. E. Turneaure gives it as his opinion that stirrups, whether vertical or inclined, only become effective at the "yield point" of the steel members. That, of course, means long after the specimen has ceased to retain the mechanical properties of a beam.

In the year 1908 Professor A. N. Talbot tested to destruction two large beams each 25 ft. long, 6 ft. 3 in. wide and 2 ft. 10 in. deep, similar in all respects, except that one beam was without stirrups and had some of its reinforcing bars bent up rather sharply and close to each end. The other beam was provided with numerous vertical stirrups and the ends of the reinforcing bars were bent up at a flatter inclination and further from the supports. The results of the tests from various loadings appear to show but little or no difference, as regards cracks in the concrete, up to about three-fourths of the ultimate load; and at the ultimate load in each case the beam with stirrups carried only about 5 per cent. more than the beam without them.

Viewing the useful effect of many systems of web-reinforcement in a practical manner, it seems possible that if the metal so employed and the expense of fitting and fixing it were put into extra reinforcing bars—the safe loading of the beam still remaining the same as before such alteration—the reduction of strain at the extreme "tension" surface of the concrete would be so considerable that in ordinary beams there would be no danger from the effects of "diagonal tension."

Proposed Methods for Web-Reinforcements.—In no system of web-reinforcement has it yet been possible to determine how much and in what manner the various parts are beneficially affecting the beam at its maximum safe load, but the following proposals, which are founded on purely theoretical considerations, are put forward as suggestions for strengthening the stretched concrete situated at some little distance from the reinforcement to an extent almost equal to that afforded to it at and near to the reinforcement.

The principal object to be arrived at is the preservation from rupture of the concrete in tension between the reinforcement and the neutral axis. Now, as the stresses in that part of a beam are chiefly due to flexure and are consequently of the direct horizontal kind, suppose, say about midway between the reinforcement and the neutral axis, there be incorporated in the mass of concrete a form of "intermediate reinforcement" composed of fairly short straight rods, about the size of ordinary telegraph wires, laid at close distances apart on a horizontal plane and from side to side in breadth of the beam, and as far along its length as might be considered necessary. This plane of "intermediate reinforcement" would have the same effect in strengthening the concrete in tension in the body of the beam as the main reinforcement has at its extreme stretched surface. Further, if severe "diagonal tension" were apprehended the strain on the concrete could be equalized or averaged by the addition of more short rods or thick wires placed in the concrete fairly closely together at any desired inclination—say at 30° to the horizon—and extending from about the plane of the main reinforcement to a little above the neutral axis. Those thick wires would not be attached to the reinforcing bars, therefore the whole mass of concrete would be free to set properly without any hindrance from unnecessary connections. Such inclined short rods or thick wires might be straight or curved as desired, and their especial function would be to act simply as skewers, each one becoming a nucleus of support for the benefit of the concrete surrounding it.

Another suggested method for assisting the interior part of the concrete to withstand better than in its plain state the effects of direct " horizontal " and " diagonal " tension, is by the employment of " expanded metal," which, although it has often been successfully used in combination with concrete, has not, it is believed, yet been tried in the following manner :—Suppose short sections of a light make of that material to be introduced into the mass of concrete and placed vertically and longitudinally in it at fairly close distances apart from side to side of a beam, and in depth from a little above the neutral axis to about the plane of the reinforcement—care being taken that no rigid connections shall be in existence anywhere—the concrete would be so much " protected " and strengthened that further " web-reinforcement " would probably be unnecessary.

By the employment of some such " supple " system of web-reinforcement as sketched out above, it is anticipated that the concrete everywhere would be maintained at its full strength and there would be nothing to restrain its proper and natural setting. There would be freedom for the insertion of as much or as little " web-reinforcement " as might be desired ; there would be freedom from any interference with the main reinforcing bars ; and there would be freedom for the manipulation of the various pieces and parts into place during construction.

Looking at the subject of web-reinforcement in a general manner, it would appear that the duty of any " system " is mainly, if not entirely, to assist—by its binding and skewering properties—the mass of concrete in resisting the effects of tension, whether due to horizontal, diagonal or shearing strains ; and further, from a theoretical point of view it seems difficult to consider the members of any such " system " as being in some sense analogous to the diagonals of an ordinary open braced iron or steel girder so long as the concrete remains intact.

NOTES ON MR. FYSON'S ARTICLE ON SHEARING RESISTANCE OF REINFORCED CONCRETE BEAMS.

By Dr. OSCAR FABER, O.B.E.

It is always refreshing to see a man boldly set himself against the accumulated experience of a profession, and when, as in Mr. Fyson's case, he is able to present his treatment with great mathematical skill, his article merits study and consideration, besides exciting our admiration and interest. This by no means involves any admission that Mr. Fyson's theory or treatment should be substituted for those at present in use, as may, perhaps, be gathered later.

Where Mr. Fyson breaks away is at the outset, when he declines to consider the whole tensile stress in a beam as taken in the steel and the tensile resistance of the concrete neglected. Mr. Fyson's treatment all assumes that the concrete may be called upon to carry very substantial tension, and his treatment only applies to the beam before the first hair cracks have occurred.

Now in practice, hair cracks occur in reinforced concrete structures comparatively early. In laboratory tests such as my own to which Mr. Fyson refers, the first crack often occurs at about half the ultimate load. But a laboratory experiment is free to contract without hindrance as the concrete sets and dries, and to expand or contract without hindrance as the temperature rises or falls.

In structures of magnitude, on the other hand, there is always considerable restraint. For example, a concrete floor constructed on brick walls has the same tendency to contract during setting, but as the walls are often substantial, and stiffened with cross walls, they do not permit of contraction of the floor without the formation of considerable tensile stresses, and for this reason, actual structures often show hair cracks at loads much less than half the ultimate, in fact, they *often contain hair cracks before any loading takes place.*

It does not follow from this that the stability of the work has been endangered by these hair cracks—the whole experience of reinforced concrete engineers is against such a conclusion, since thousands of structures, after showing hair cracks, continue to do all that they were designed for in a perfectly satisfactory manner.

Yet all such structures put themselves outside the range of Mr. Fyson's treatment, though the usual treatment, in which tension in the concrete is neglected, then applies in full force, and provided the structures were designed in accordance with this usual theory, the cracks can be regarded without concern.

Another point important in practice is the consideration that for obvious reasons the actual construction will proceed in stages, and that the joint between the old and new concrete never has more than a fraction of the tensile strength of the concrete elsewhere, as shown both by direct laboratory tests and in practice by the frequency with which contraction cracks follow the lines where construction was temporarily stopped. At all such joints, Mr. Fyson's treatment will have little significance for the same reasons as already explained, and yet such joints are a practical necessity.

Mr. Fyson claims that tests to destruction give little indication of the actual stresses existing before the concrete cracks. This is true, but I think Mr. Fyson is wrong when he goes on to state that only the stresses existing before the concrete cracks are material. If one had to choose between the two, surely the stresses after cracking are the more important, because these indicate what factor of safety the structure has, whereas the former, being based on the assumption of tensile strength in concrete, though it is known this strength will be lost long before failure, can give no knowledge of the factor of safety.

It is quite true, that when the usual theory is adopted, and tension in the concrete neglected, that in some sections the actual conditions will be better, and some tension in the concrete may exist, but this only means in practice that the deflection is a little less than calculated on the assumption of no tension in concrete. On the other hand, to adopt Mr. Fyson's attitude that once a hair crack has occurred, the structure has no interest for him, would involve the condemnation of nearly every existing reinforced concrete structure which is giving complete satisfaction, and would be almost impossible to satisfy in practice even if considerations of econom ywere completely ignored, owing to the cracks due, not to loading, but to contraction, temperature changes, and construction joints.

It would be interesting to know how Mr. Fyson would propose to design a structure containing thousands of members in the few weeks which alone are available for such design in practice, if the calculation of a 12 by 8 rectangular beam reinforced with 2–$\frac{3}{4}$ in. rods occupies the many pages of abstruse calculations, only a very few of which are given in the article, the rest having been calculated by him and only the results given. Yet its resistance can be calculated in two lines by any experienced designer on the usual method, and the results of my experiments, which Mr. Fyson quotes from, was to show an almost constant factor of safety over a very wide range indeed.

The above remarks were intended chiefly to apply to Mr. Fyson's calculations of Moments of Resistance. But they apply equally to Shear.

I have given a method of design by which the shear resistance due to inclined bars, stirrups, inclined compression in the concrete, can be calculated in three lines and added together, and have shown that the result agrees with experiments by calculating the strength of a very large number of beams, under greatly varying conditions, by this method, and then testing the beams and showing that the expected factor of safety was very consistently obtained. This has practical importance in designing.

Mr. Fyson, apparently, considers stirrups and bent-up rods, not as adding a finite and readily calculable quantity to the resistance of a beam, but " as extra factors of safety." I take this to mean that to carry a given load he would want to resist the whole shear by diagonal tension in the concrete and neglect the resistance of stirrups or bent-up bars. This, of course, would lead to very heavy and extravagant construction, and it is safe to say that had the industry designed on these lines in the early days, and not on the results of tests to destruction, the present state of the industry would never have been reached.

In conclusion, then, it appears to me that the position is summed up as follows :

(1) Concrete readily develops hair cracks, due to shock, contraction, temperature changes, and loading.

(2) If its strength were dependent on such cracks not being formed, it would be a dangerous material.

(3) Fortunately, however, it is quite reliable after such cracks have formed.

(4) The only safe method of calculation is, therefore, that in which concrete is neglected as regards resistance to tension, and to rely on it, as Mr. Fyson does, would be dangerous.

(5) The usual methods of calculating resistance moments, and the methods I suggested for calculating shearing resistances, none of them rely on a resistance to tension which will break down long before the structure approaches dangerous conditions, and so far, no better methods have been shown by experiment or practice to give more consistent results.

MEMORANDUM.

Expansion Joints in Buildings.—Expansion joints in large concrete buildings are discussed by G. W. Maker, of the Aberthaw Construction Co., in *Successful Methods*, from which the following is quoted :—

" Some engineers advise that expansion joints should be provided every 100 ft. to take care of the contraction and expansion of structures built of concrete. However, there can be found in nearly every city of magnitude concrete structures 300 ft. long constructed without expansion joints which have successfully withstood the changes due to variations in temperature and humidity. These structures indicate that if proper attention is paid to the method of reinforcement the difficulty can be overcome within wider limits than 100 ft.

" Examples can be found of structures 400 ft. long that have shown no severe cracks after having passed through the intense heat of two summers and the severe cold of winter.

" In general, however, for buildings over three storeys high and over 300 ft. long, expansion joints should be provided. These joints should completely separate the buildings one from the other, so that the different units will be free to move independently and of their own accord. This should preferably be done by means of double columns and double beams. The columns may rest upon the same footing as the movement would be practically negligible below the ground.

" The adjacent column and beam should be cast after the forms for the first have been removed. In order to prevent the weather from coming through the space between the outside wall columns and the roof beams, a metal diaphragm should be provided of either sheet lead or copper. This should be bent in the form of a " **V** " so as to allow it to expand as the two different units of the building move. The joints at the floor level should be protected by angle guards, which prohibit the edge of the concrete from being broken. Sliding plates should be provided to prevent the dirt from sifting through to the floor below.

" Another method of accomplishing this same result in providing a successful weather stop for the columns is to cast two grooves in the first section approximately 3 in. by 3 in., and coating with paint or pitch. In building the next section a tongue is formed by the concrete entering the grooves previously left."

Interior View of Building for the Continental Car Co., Syracuse.

THE AMERICAN "FLAT SLAB" TYPE OF BUILDING: ITS ADVANTAGES AND DESIGN.

By A. E WYNN, B.Sc., Assoc. M. Am. Soc. C.E.

While on a visit to England last winter the writer was struck with the absence of reinforced concrete buildings built on the " Flat Slab " system, and was particularly surprised to learn that this type of construction was prohibited by the L.C.C. Building Code. There is little or no mention given to it in any of the English text-books on reinforced concrete. This seems very surprising to any one from America, where this system is so common, and which, in fact, has almost entirely superseded the old beam and girder design for certain types of buildings.

The writer attributes the rapid growth in the use of reinforced concrete for buildings in the United States largely to the adoption of this " Flat Slab " type of design.

It is with the idea of giving English engineers some knowledge of the advantages and design of this system that this article is written. At this time, in particular, when reinforced concrete is being considered more than ever before in England, and when economy of construction is of so much importance, the adoption of new and economical methods should receive every consideration.

The first " Flat Slab " building in America was erected in 1903, Mr. C. A. P. Turner being the pioneer engineer of this design. Since then its growth has been extraordinarily rapid, until at the present time at least 80 per cent. of the new reinforced concrete buildings (with live loads of 100 lb. or more per sq. ft.) are built of this type.

It is used principally in factories, warehouses, cold storage plants, garages and other buildings where the live load is 100 lb. or over per sq. ft., and where the floors are not much cut up by openings.

Advantages.—The chief reasons for using it are economic ones.

Economy in construction is the first consideration. For average conditions it is more economical than beam and girder type, and the difference in cost is more marked as the live load increases.

The formwork is much simpler and more rapid, and there is not so much waste. There is a considerable saving in storey height and in the total height of a multiple storey building, as there are no projecting beams. Due to the absence of beams placing of steel and concrete proceed more rapidly.

Apart from economy in construction there is a saving in cost on the installation of the mechanical equipment due to the flat ceiling. An automatic sprinkler system can be installed at less cost, and is far more efficient since the flow of the water is not obstructed by beams. Shafting, piping, wiring, overhead conveyor systems, etc., can all be installed more easily, as there are no beams and girders with their different depths to avoid.

Other advantages to the owner are better fire protection, better lighting, greater storage capacity, increased safety against overloading of floors, and a better looking interior to his building.

In case of a bad fire a flat slab building will suffer less than one of the beam and girder type, as there are no corners of columns and beams, which points are always the first to spall and endanger the building. There are no beams to obstruct the passage of daylight, and as the windows can be carried up to the underside of the floors good illumination can be obtained for the maximum width of building. Indirect lighting can be used with the maximum efficiency as there is greater reflection of light from the flat surface.

In a warehouse goods can be stored right up to the ceiling if necessary. Owing to the great number of small bars running in several directions, danger of collapse from overload is minimized as the stress is better distributed. Most of the misplacing of steel occurs in the beams and girders, and as these do not occur in "flat slab" design there is much less possibility of misplacement and perhaps consequent failure. Also, as all the steel is in plain view it can be more easily and quickly inspected.

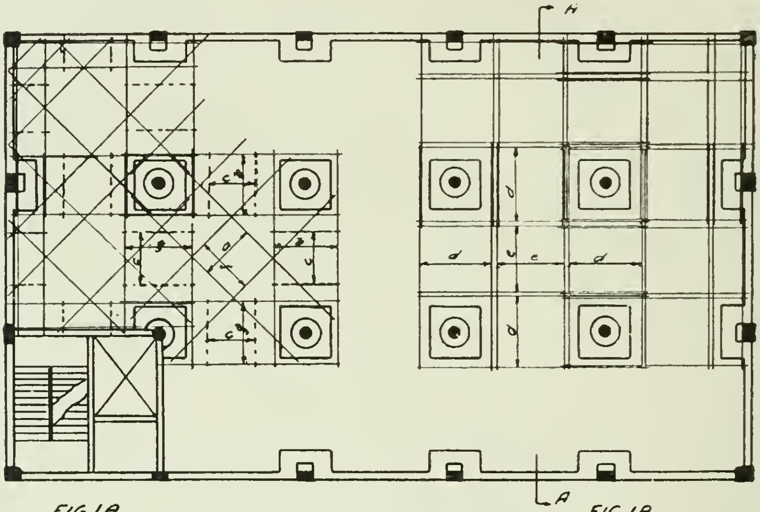


FIG. 1A TYPICAL FLOOR PLAN (from below) FIG. 1B

FIG. 1

General Description.—A "flat slab" floor consists essentially of a reinforced concrete slab of uniform thickness, supported symmetrically on columns the tops of which are splayed out to form caps underneath the floor. Above the cap there may or may not be an increased thickness of slab forming a "depressed panel." All loads on the floor are transmitted directly to the columns without the agency of beams or girders (see *Figs.* 1 and 2).

The reinforcement usually consists of bands of small bars running from column to column, in the bottom of the slab at the centre of the bay and in the top of the slab over the column.

The bays are usually square or nearly so, with the columns spaced about 20 ft. apart. The building should be at least three bays wide, if possible.

Theory.—The actual action of "flat slab" floors is not fully known though several analyses have been put forward. The stresses are exceedingly complex so that it is practically impossible to work out any exact formulæ.

Fig. 3 will give a general idea of the way in which the slabs act. The lines join up points of equal deflection and are in fact contours. It will be seen that in the centre of the bay the top surface is concave while over the columns it is convex. Deformation of the fibres is equal so that the fibre stresses act perpendicular to the equal deflection lines. The usual way of resisting these stresses is by placing bands of straight reinforcing bars cutting these contour lines approximately at right angles.

It has been found by numerous tests that the points of inflection lie on a line around the column head enclosing an area which is between a square and its inscribed circle. The minimum distance between opposite inflection points is about 0·5 *L* and the maximum about 0·6 *L* where *L* is the length of a panel side.

To simplify the design, since the bending moment along the line of inflection is zero, it is possible to separate the slab into simple parts along this line and we have circular cantilevers at the columns, suspended slabs between columns and a centre slab supported on four sides. In the cantilever portions the stresses act in both a radial and a circumferential direction, and are resisted by bands of bars in the top of the slab. The suspended slabs between columns are stressed principally in one direction and are reinforced by a band of bars in the bottom of the slab. There are also secondary stresses due to shrinkage, temperature changes and cross bending; these are resisted by a band at right angles and in the top of the slab. The centre slab is stressed in all directions and is usually reinforced with two bands at right angles in the bottom of the slab.

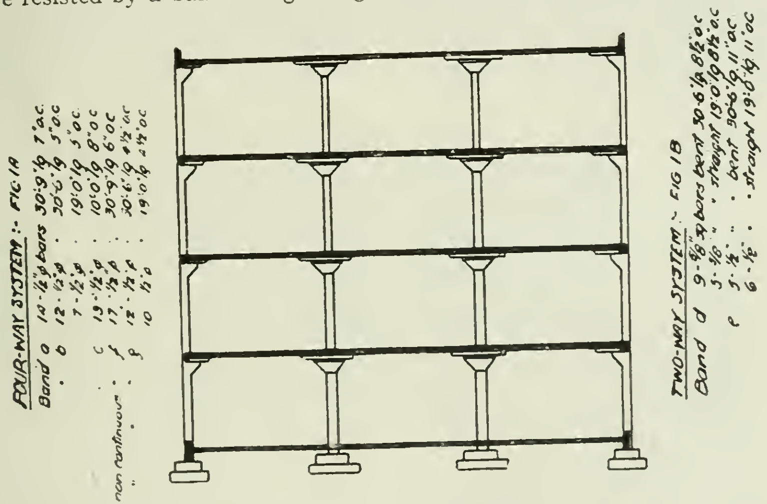

FOUR-WAY SYSTEM :- FIG 1A
Band a 10-½"φ bars 30'-9" lg 7" o.c.
" b 12-½"φ " 30'-6" lg 5" o.c.
7-½"φ " 19'-0" lg 5" o.c.
" c 19-½"φ " 10'-0" lg 8" o.c.
" d 17-½"φ " 30'-9" lg 6" o.c.
non continuous " e 13-½"φ " 30'-6" lg 4½" o.c.
" f 10 ½"φ " 19'-0" lg 4½" o.c.
TWO-WAY SYSTEM :- FIG 1B
Band d 9-⅝"φ bars bent 30'-6" lg 8½" o.c.
5-⅝" " straight 19'-0" lg 8½" o.c.
e 5-½" " bent 30'-6" lg 11" o.c.
6-½" " straight 19'-0" lg 11" o.c.

FIG. 2. SECTION A.A.

In attempting to analyse the stresses mathematically one of three methods is usually chosen: (1) dividing the slab into strips and treating them as continuous beams; (2) dividing the slab into circular plates enclosed by the lines of inflection and supported at their centres by the columns and considering them uniformly loaded over their areas and peripheries; (3) considering the slab as a plate supported symmetrically at points. The first two methods give moments and stresses in fair accordance with those found from actual tests on buildings. These analyses will not be given in this article as they would occupy several pages, and as they are not used in design they are of only mathematical interest.

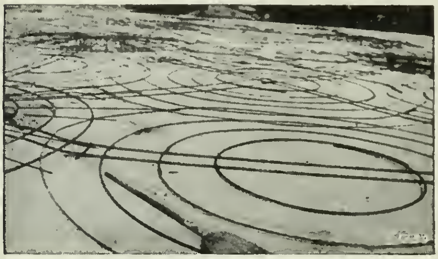
All formulæ used in designing "flat slab" floors are empirical, based on the results of numerous tests of actual buildings. They however can be checked closely by the first of the above methods.

Before giving these formulæ we will consider a few of the systems of reinforcing in use.

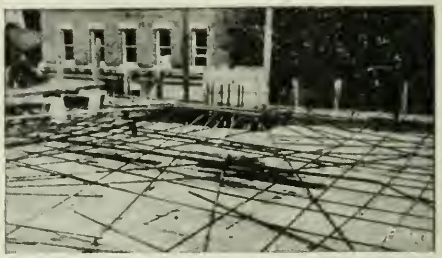
Systems.—The two usual methods are the "two-way" and the "four-way" systems of reinforcing. Until last year these were patented but the patents have now lapsed.

Another method, the S.M.I. system, has probably the best theoretical distribution of steel and consists of circular hoops in combination with bars radiating from the columns. The steel is rather difficult to place and the system is not so extensively used as the first two systems.

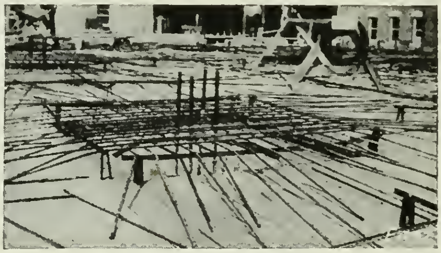
The "two-way" and "four-way" systems only will be treated here as these are the two in common use.



THE S.M.I. SYSTEM, CONSISTING OF CIRCULAR HOOPS AND BARS RADIATING FROM THE COLUMNS.



TRUSCON SYSTEM, CONSISTING OF RADIAL BARS OVER THE COLUMN AND TWO RECTANGULAR BANDS IN THE CENTRE OF THE BARS.



TRUSCON SYSTEM. NOTE SPACER BARS OF TEE SECTION CARRIED BY STEEL CHAIRS.

The bending moment coefficients vary slightly with different building regulations and authorities, chiefly in the proportion of the positive and negative moments to the total moment.

The Chicago Building Code is recognized as the authority on "flat slab" design, and is used more than any other. Most other regulations are modifications of this Code. The Chicago Code is most conservative and is absolutely safe to use.

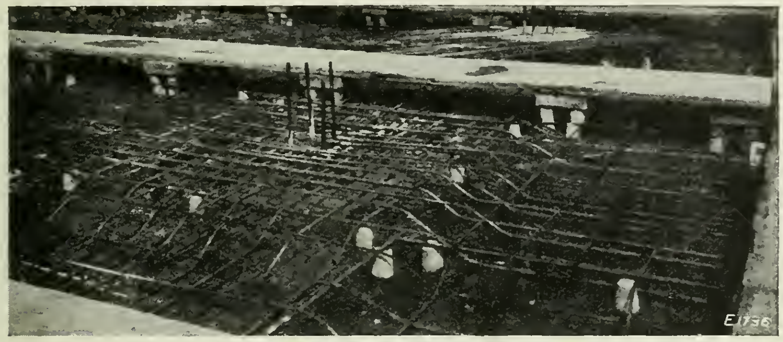
All the formulæ given below are those recommended by the Chicago regulations.

Any of these systems can be designed with or without depressed panels. Depressed panels help to stiffen the structure, are more economical of steel and concrete and are more often used than not. It will be taken here as standard practice to use them and afterwards the modifications in design for slabs without "depressed panels" will be given.

The "Two-Way" System (*Fig.* 1B).—In this system the bands of bars run in only two directions. There are two bands at right angles, one in each centre strip *B*, part of the bars being bent up into the top of the slab to provide negative moment over the cross bands *A*. There are also two bands, one in each column strip *A*, part or all of the bars being bent up to provide negative reinforcement over the column head.

The "Four-Way" System (*Fig.* 1A).—This system consists of two diagonal bands and two cross bands ; most or all the bars are in the bottom of the slab at the centre of the panel and in the top of the slab at the columns, bending up at about the quarter points. In addition there are short top bands over each cross band and at right angles to them.

Either of these systems are used according to the preference of the designer.


E1736

THE TWO-WAY SYSTEM.

E1742

NEW BUILDING FOR THE HAYNES AUTOMOBILE COMPANY, KOKOMO, IND. TYPICAL FOUR-WAY SYSTEM.

The " four-way " is more economical of steel, bars can be used in their full mill length and do not require bending as they are small in section and sag from top to bottom of slab by their own weight. In the " two-way " the bars are larger in section and have to be bent ; it is perhaps a little more economical to place and is best suited to heavy live loads.

From actual tests there is little difference in the stresses developed in the two systems.

General Formulæ for Square Panels.—These formulæ are applicable to either system.

w=uniform live+dead load per sq. ft.

L=side of square panel.

W=total panel load=wL^2.

t=thickness of slab.

t'= thickness of depressed panel.

c=diameter of col. cap at a point where it is at least $1\frac{1}{2}$ in. thick.

d=side or diameter of depressed panel.

Then minimum $t = \cdot 023 \times L \times \sqrt{w}$, never less than $L/32$ for floors.

" " " $L/40$ for roofs.

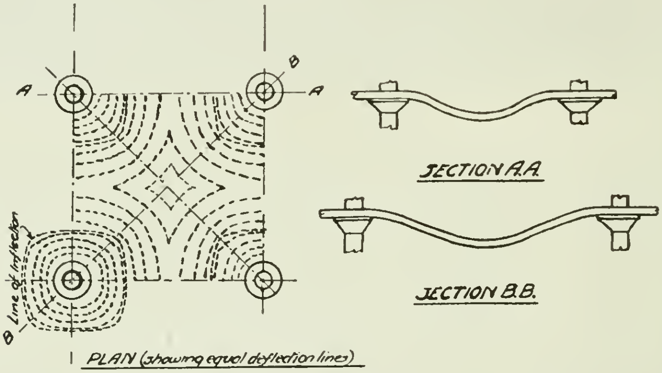
" " " 6 in.

$c = \cdot 225L$, angle side of cap makes with vertical always 45 degrees.

d=not less than $L/3$.

In designing we consider a square panel bound by the centre lines, drawn through four columns. This is then divided for design purposes into two centre strips B and two column strips A, each equal to $L/2$ in width (see *Fig.* 4).

There are two kinds of panels, interior and wall panels. An interior panel must have at least one adjoining panel on each side, that is, it is continuous on each side. A wall panel is non-continuous on one or two sides.

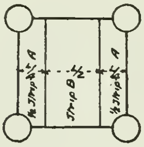


SECTION A.A.

SECTION B.B.

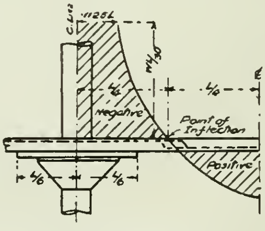
PLAN (showing equal deflection lines)

FIG. 3



PANEL STRIPS A and B
Same strips in both directions

FIG. 4.



BENDING MOMENT DIAGRAM

FIG. 5.

The bending moment diagram is shown in *Fig.* 5.

Design of Two-Way System :—Moments.

Strip A.—Negative moment for each strip at edge of column cap$= -WL/30$.
Positive moment for each strip midway between columns$=WL/60$.

Strip B.—Negative moment on line of columns for each strip$= -WL/120$.
Positive moment at middle of panel for each strip$=WL/120$.

For wall panels use the same coefficients as for interior panels, but increase the positive moments in A and B each 25 per cent.

Distribution of Steel to resist Moments.—Amount of steel to resist bending moment in any strip to be area of steel included in width of strip.

Compression in Concrete.—Width of beam assumed to resist compressive stresses over column cap shall be width of depressed panel.

Example. Interior panel 20 ft. × 20 ft. $L=20$.
Live load=200 lb. per sq. ft.
Floor finish=20 ,, ,,
Allowable stress in steel=16,000 lb. per sq. in.
,, fibre stress in concrete for $+$moments=650 lb. per sq. in.
,, ,, ,, ,, ,, $-$,, =700 ,, ,,
,, punching shear around perimeter of cap=120 ,, ,,
,, ,, ,, ,, ,, D.P.=60 ,, ,,

Assume thickness of slab $t=8$ in. Fireproofing=$\frac{3}{4}$ in.
$w=200+20+100=320$ lb. per sq. ft. $W=320\times400=128{,}000$ lb.
$t=\cdot023\times L\times\sqrt{w}=\cdot023\times20\times\sqrt{320}=8\frac{1}{4}$ in.
$c=\cdot225\times L=\cdot225\times20=4$ ft. 6 in. dia. $d=L/3=20/3=6$ ft. 8 in.

Strip *A*.—$+M=WL/60=\dfrac{128{,}000\times20}{60}=42{,}700$ ft.-lb.

effective depth $8\frac{1}{4}-1\frac{1}{4}=7$ in.

Area of steel in band$=\dfrac{42{,}700\times12}{16{,}000\times\cdot874\times7}=5\cdot24$ sq. in. Say $14\frac{5}{8}$ sq. bars.

$-M=WL/30=\dfrac{128{,}000\times20}{30}=85{,}400$ ft.-lb.

To find depth of depressed panel :—
Moment of resistance of slab at D.P.$=700/2\times6\cdot67\times\cdot396\times\cdot868(t')^2$.
$=803(t')^2$ ft.-lb.

$$\text{or } t=\sqrt{\frac{85{,}400}{803}}=10\cdot32+1\cdot5=11\cdot82, \text{ say } 12 \text{ in.}$$

Area of steel$=\dfrac{85{,}400\times12}{16{,}000\times\cdot868\times10\cdot5}=7\cdot02$ sq. in. Say $18\frac{5}{8}$ sq. bars.

To obtain these we bend up nine bars out of the fourteen from each side of the column, leaving five bars straight in the bottom of the slab.

These bent bars are to extend to a point $\frac{1}{4}L$ or 5 ft. beyond the centre line of the column.

Strip *B*.—$+M=WL/120=\dfrac{128{,}000\times20}{120}=21{,}340$ ft.-lb.

Effective depth=7 in.

Area of steel$=\dfrac{213{,}400\times12}{16{,}000\times\cdot874\times7}=2\cdot62$ sq. in, say $11\frac{1}{2}$ in. sq. bars.

$-M=WL/120=$same, say $11\frac{1}{2}$ in. sq. bars.

To obtain these bend up five or six bars from each side, extending them as before 5 ft. beyond the column.

The bars are bent up at the quarter points and are staggered so that alternate bars are either side of the line of inflection (see *Fig.* 6).

Shear around Cap$=\dfrac{128{,}000-3\cdot14\times4\cdot5^2/4\times320}{3\cdot14\times54\times10\cdot5}=70$ lb. sq. in.

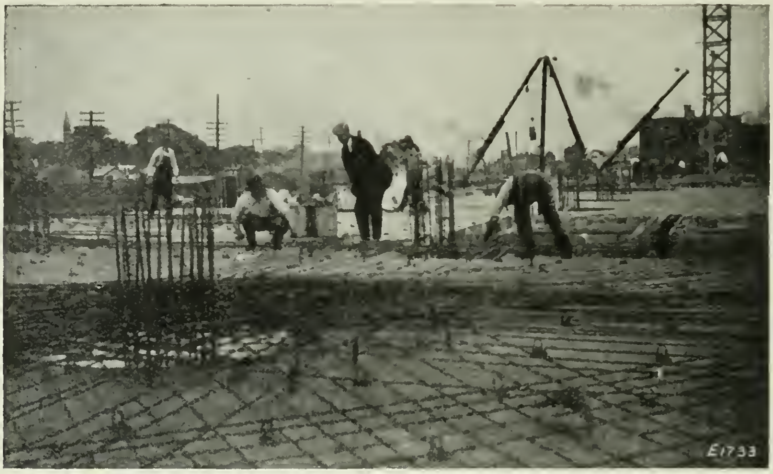
,, ,, D.P.$=\dfrac{128{,}000-6\cdot67^2\times320}{4\times80\times7\times\cdot874}=58$ lb. sq. in.

The width of the bands will be $L/2$ or 10 ft. This completes the design of the panel.

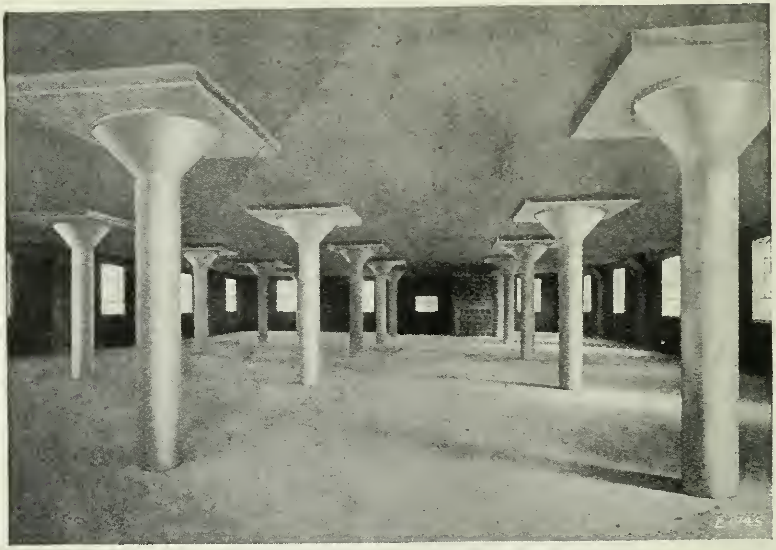
A wall panel is designed the same way, only the positive moments are increased 25 per cent. and against the lintel there will be a half band *A*.

Design of Four-Way System. Moments:—

Strip *A*.—Negative moment for each strip at edge of column cap$=-WL/30$.
Positive moment for each strip midway between columns$=WL/80$.



Four-Way System showing Inserts for carrying Pipes and Shafting.



Interior View of a Factory—Without Depressed Panel.

Strip *B*.—Negative moment on line of columns$=-WL/120$.
Positive moment middle of panel$=WL/120$.

As before, for wall panels increase the bending moments 25 per cent.

(*To be continued.*)

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

COUNCIL AND COMMITTEE MEETINGS FOR FEBRUARY AND MARCH.

February	3rd.	R.C. Practice Standing Committee, at 4 p.m. Science Standing Committee, at 5.30 p.m.
,,	10th.	Literature Standing Committee, at 5.30 p.m.
,,	17th.	Finance and General Purposes Committee, at 5.30 p.m.
,,	24th.	Council, at 5.30 p.m. Ordinary General Meeting, at 7.30 p.m. Paper by Mr. E. S. Andrews, B.Sc. (Eng.), M.C.I., entitled "Methods of Securing Impermeability in Concrete." (Lantern.)
March	3rd.	R.C. Practice Standing Committee, at 4 p.m. Science Standing Committee, at 5.30 p.m.
,,	10th.	Literature Standing Committee, at 5.30 p.m.
,,	17th.	Finance and General Purposes Committee, at 5.30 p.m.
,,	31st.	Council, at 5.30 p.m. Ordinary General Meeting, at 7.30 p.m. Paper by Mr. Sven Bylander, M.C.I., entitled "Stresses in Structural Steel."

RESULTS OF THE EXAMINATIONS.

The following candidates were successful in passing the Institute's Examinations in 1920:—

For **Associate-Membership**:—ATTRILL, Albert Henry, B.Sc. (Eng.).
CRAMER, William.
MORTON, Harry.
O'CONNELL, Terence Joseph.
ROW, Bina Venkatareddy Naranaya (Parts I. and II.).
ROUGHAN, James Joseph, B.E., B.Sc.
SENIOR, Edward Powell.
SHORE, Albert William (Parts I. and II.).

For **Graduateship**:—CROWTHER, Fred Sefton.
SCHOFIELD, Reginald William.

EXHIBITION OF CONCRETE AND REINFORCED CONCRETE ARTICLES.

The Concrete Utilities Bureau has on permanent exhibition at 143, Grosvenor Road (close to Vauxhall Bridge, S.W.1) a great variety of Concrete and R.C. Concrete articles. These may be inspected any day (Monday to Friday inclusive) between the hours of 10 a.m. and 4 p.m., by mentioning the Secretary of the Concrete Institute as introducing the visitor.

CLASSES IN STRUCTURAL ENGINEERING.

For the information of our Members in general, we are noting here some brief details as to Classes, which are held at various Institutes in the subjects of Structural Engineering, Concrete and Reinforced Concrete :—

BOROUGH POLYTECHNIC INSTITUTE, Borough Road, S.E.

The Principles of Mechanics, on Thursdays from 7.30 to 9.30 p.m.—Lecturer, Mr. G. Goodwill, B.Sc.

Engineering Science.—Lecturers, Messrs. G. E. Draycott, H. A. Boultbee and E. L. Joselin.

Applied Mechanics.—Teachers, Messrs. Draycott, Boultbee, G. W. Bird and F. G. Smith.

Structural Engineering Drawing and Theory of Structures.—3rd and 4th year work include some Reinforced Concrete work.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY and CITY AND GUILDS OF LONDON INSTITUTE, Exhibition Road, S.W.

Teachers.—Mr. M. G. Weekes, M.Inst.C.E., and Mr. R. Freeman, M.Inst. C.E., M.Am.Soc.C.E. (of Messrs. Sir Douglas Fox and Partners).

LONDON COUNTY COUNCIL CENTRAL SCHOOL OF ARTS AND CRAFTS, Southampton Row, W.C.

Structural Mechanics.—Lecturer, Mr. E. S. Andrews, B.Sc. (Eng.)., M.C.I.

LONDON COUNTY COUNCIL, WESTMINSTER TECHNICAL INSTITUTE, Vincent Square, S.W.

Structural Engineering.—Teachers, Messrs. J. Stuart Ker and E. H. Sprague. Lecture, Practice and Drawing courses.

There is an advanced Course in Structural Design in Reinforced Concrete.

The Design of Steel Frame buildings (with particular reference to the requirements of the London Building Acts). Lecturer, Mr. Ewart S. Andrews, B.Sc., M.C.I.

NORTHERN POLYTECHNIC INSTITUTE, Holloway Road, N.

Structural Steel and Ferro-Concrete.—Conducted by Mr. W. C. Cocking, M.C.I., in the Senior Day School.

Mechanics of Structures, Graphical Statics and Ferro-Concrete.—Conducted by Mr. R. Graham Keevill, A.M.I.Mech.E., M.C.I., in the Evening School.

UNIVERSITY OF LONDON : GOLDSMITHS' COLLEGE, New Cross, S.E.

Classes in Structural Design and Theory of Structures, which are included in the Mechanical Engineering and Constructional Engineering courses.

UNIVERSITY OF LONDON : UNIVERSITY COLLEGE, Gower Street, W.C.

Engineering Drawing and Design.—Professors, Dr. E. G. Coker and Mr. H. P. Philpot.

Civil Engineering.—Reinforced Concrete. Professor, Mr. Ernest R. Matthews, A.M.Inst.C.E., M.C.I.

There is also now in progress a Course of Lectures on Reinforced Concrete with practical Laboratory work, which is being conducted by Dr. Oscar Faber, O.B.E., D.Sc., M.C.I.

WIMBLEDON TECHNICAL INSTITUTE AND SCHOOL OF ART, Gladstone Road.

A Class of Structural Engineering is arranged here.

CONCRETE COTTAGE BUILDING.

HAYES HOUSING SCHEME.

THE history of housing at Hayes is one of unusual interest, both from the point of view of the concrete specialist, for it shows how concrete has proved ultimately successful while other systems failed, and from the point of view of housing generally, for already before the war the district was faced with various difficulties which it had set out to solve. Seventeen years ago the district was, for the most part, agricultural, the only industry being that of stock brick-making. In consequence of this industry a large number of one-storey cottages were erected for the accommodation of the brick-makers from the refuse and shuffs from the brickfields; these cottages remained after the brick-earth was worked out and the works closed, and became inhabited by agricultural labourers.

The first housing survey was made by this Authority after the passing of the Housing, Town Planning, etc., Act of 1909, and it was found that these houses were unfit for habitation. Meanwhile the southern portion of the district had developed rapidly into a manufacturing area; it therefore became necessary to build, and the first housing scheme of 51 houses was begun in 1911, at an average cost of £220. The next scheme was to have been begun just before the war, but was delayed and not completed until March 1920.

During the war Hayes developed as a munition centre and some 10,000 people came to work in the factories, and the shortage of accommodation became so acute that in 1915 the Authority sought permission to build, but the cost was too high and the scheme did not mature. The need, according to the survey made on the passing of the 1919 Act, was 2,000 houses. The scheme prepared in 1915 was re-modelled and made to accord with present-day standards. The area of the site is about 147 acres and the number of houses included on the layout plan is 1,255 (see *Fig.* 1). The first brick was laid by Dr. Addison on February 20, 1920, and it was then hoped that the contractors, Sir Robert McAlpine & Sons, would be able to give a good output, and a large quantity of plant was brought on to the site, but it was found impossible to obtain an adequate supply of labour.

At this point it was decided to employ other methods of construction. It was useless to attempt a concrete block construction since the use of the block entailed the service of a bricklayer, of whom there was such a shortage. It was agreed to erect 100 steel-framed houses on the Dorman Long principle and 100 on some other concrete system. Various methods were tried until a satisfactory result was obtained, and as these may be of particular interest to those seeking for a means of economizing in skilled labour, a short description will be given of each. The first comprised the employment of a special mould that was used for casting a block "in situ," a semi-dry mixture being employed. It soon became apparent,

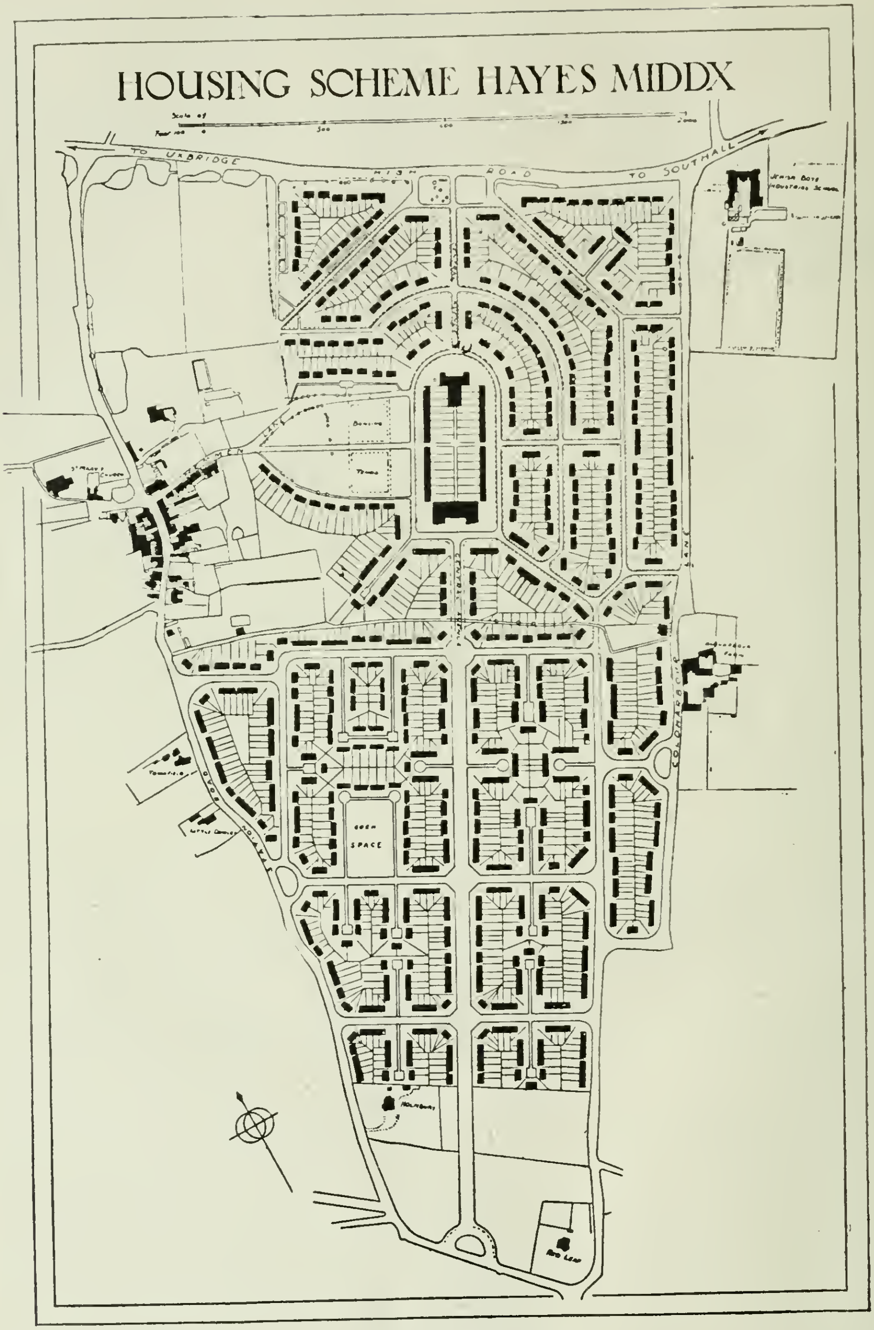
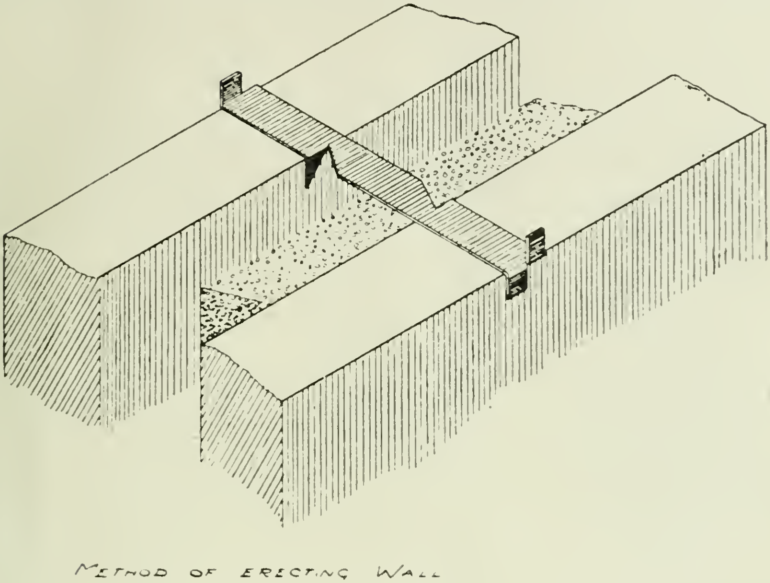
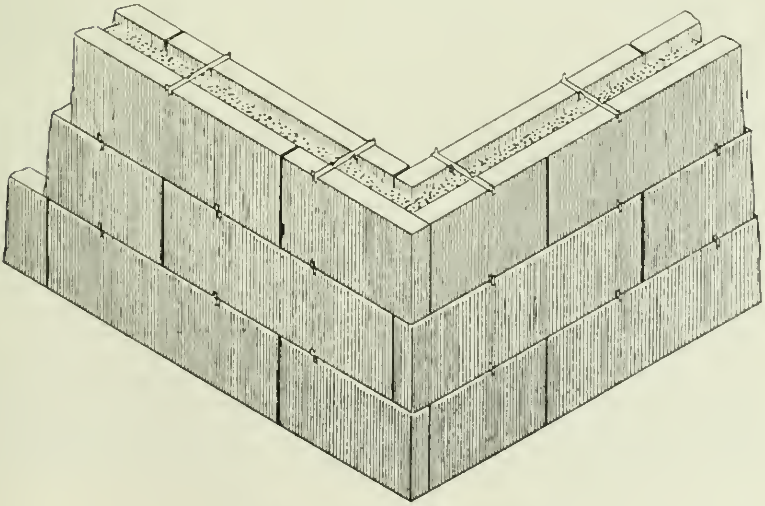


Fig. 1. Layout Plan.
Hayes Housing Scheme.

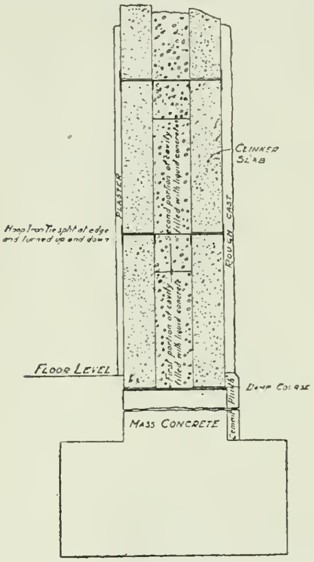
however, that with this system considerable difficulty existed in maintaining alignment; moreover, at first floor joist level it was found that the mould was useless, and it became necessary to complete the houses by another method. An attempt was then made to construct a partly hollow wall with a movable mould, but this proved no more successful than the former method.





Figs. 2 & 3 Fidler System of Construction.
HAYES HOUSING SCHEME.

Ordinary wood shuttering was then tried, and a wall composed of two 3 in. slabs with a 3 in. cavity, the two leaves being bound by galvanized iron wall ties, was built. This again was doomed to failure owing to the high cost entailed in erecting and striking the shuttering. The next experiment was with a solid wall. In order to overcome the nuisance of condensation it was decided to use two mixtures, the outer one being 5 in. thick, and of ballast concrete, the inner 3 in. thick, and of klinker aggregate. The two portions of the wall were kept separate by means of a thin steel plate, which was at once withdrawn so soon as the mixture was placed in the shuttering. It was found, however, that there was insufficient adhesion between the two parts of the wall, due, probably, to the different rate of moisture absorption and of expansion in the different aggregates. The shuttering was 12 ft. by 3 ft., fastened together by bolts, which of course passed through the wall. These were withdrawn as the shuttering was struck.


Clinker Slab
Plaster
Rough Cast
Second portion of cavity filled with liquid concrete
First portion of cavity filled with liquid concrete
Hoop Iron Tie split at edge and turned up and down
Floor Level
Damp Course
Plinth
Cement
Mass Concrete

SECTION OF WALL GROUND FLOOR LEVEL

Fig. 4.

Yet another attempt was made on the same lines with climbing shuttering, which consists of a double-faced metal shuttering, fixed top and bottom by wires. When a section is completed the lower wires are cut, and leaving the upper wires intact the shuttering is raised. In so doing it describes a semi-circle; the height of the shuttering being the radius. This was found to interfere with the scaffolding, and was in turn abandoned.

Before describing the final and successful experiment, it would be well to draw attention to the original objective, which may have been lost sight of by the reader in following the foregoing attempts. The first difficulty arose through shortage of skilled labour. A system, therefore, was required which could be employed by unskilled labour. This ruled out the usual block construction. The ensuing attempts failed partly from expense, partly from difficulty of alignment, and partly from difficulties encountered at first floor joist level.

The successful system is a combination of two of the rejected systems, which by a clever combination overcome all the above-mentioned obstacles. The method was invented by Mr. D. C. Fidler, the Surveyor to the Hayes U.D.C., and has since become known as the Fidler system of concrete construction. It consists of a combination of the concrete block and the " in situ " systems, and the key to its success depends upon the invention of a metal wall-tie, which performs a twofold function: that of preventing the inner and outer leaves spreading when the cavity is filled with liquid concrete, and of rendering the erection of the blocks almost fool-proof, since these ties or clips hold the blocks so precisely in position that they can be built up by unskilled labour.

Fig. 2 shows the tie in position; it will be observed that by means of the upwards and downwards turn at the extremity, and the triangular punched portions on the inside of the block, the position of these is exactly maintained. *Fig.* 3

shows a piece of walling, while *Fig.* 4 is a section of the wall. The blocks are laid dry, but the use of the liquid concrete makes the whole into a monolithic mass. The clips on the outer face of the wall are cut off flush with the surface as the work proceeds. The aggregate for the blocks is klinker ; in this way a good fixing is obtained for joinery. The outer surface is rough-casted or cement rendered, or the outer blocks can be cast with a waterproof face ; furthermore, the porous aggregate prevents condensation.

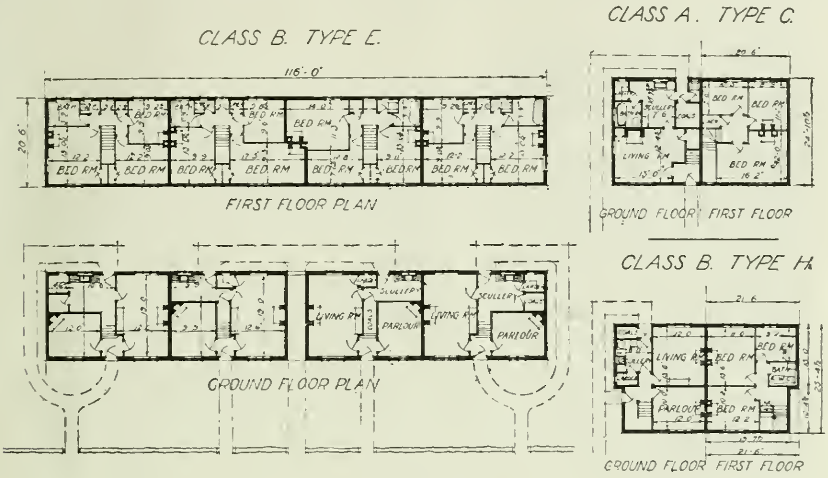


Fig. 5. Plans.
Hayes Housing Scheme.

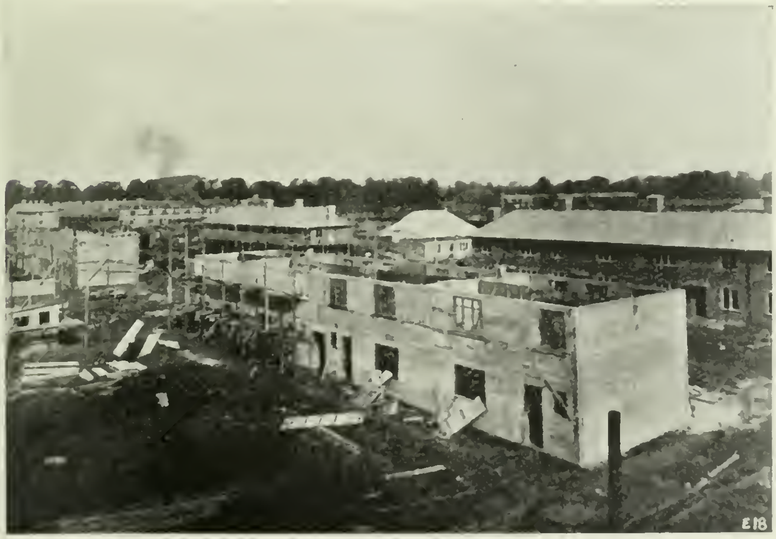


Fig. 6. Houses erected with solid Concrete Walls and Timber Shuttering.
Hayes Housing Scheme.

The actual method of procedure is to erect a solid concrete wall upon foundations to damp course level; above this the cavity wall, filled in solid as the work proceeds, is built. To secure alignment wood profiles are erected at the corners of the building. The slabs are then built to a line drawn from profile to profile. The cost of this method of walling is about 14*s.* per yard super; the whole wall can be built by unskilled labour provided there be supervision at about the rate

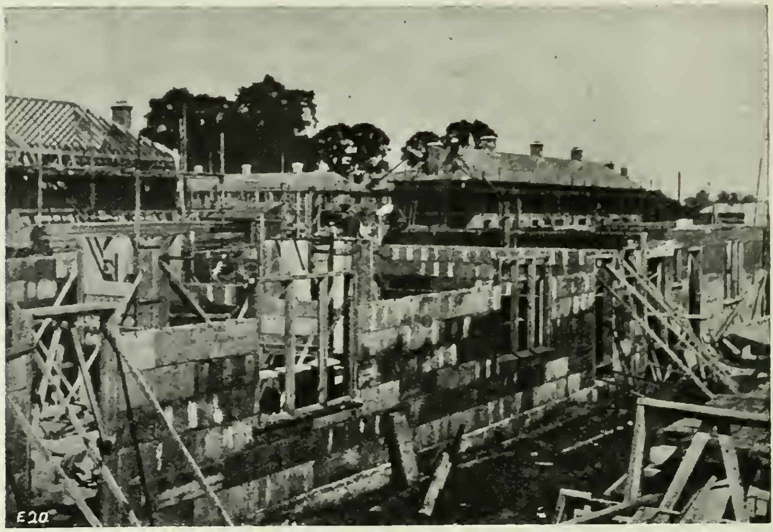


Fig. 7. Houses in course of erection on Fidler System.
HAYES HOUSING SCHEME.

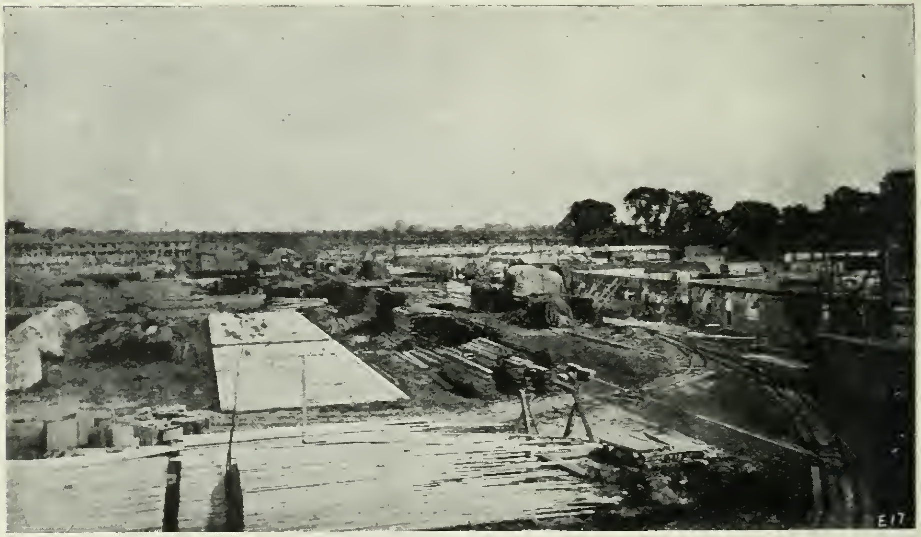


Fig. 8. General View of Site.
HAYES HOUSING SCHEME.

of one bricklayer to four labourers. The system is extremely adaptable, and the houses need not be designed to any unit dimensions. *Fig.* 5 shows various types of plans in use. In *Fig.* 6 are seen some houses in process of erection on the Fidler system. *Fig.* 8 gives a general impression of the site. The houses on the right are of the earlier type, erected with wooden shuttering. *Fig.* 7 gives a nearer view of the same type of house. At the present time there are some 800 houses in course of erection, while 52 are completed; the work in connection with the sewers is also finished. An interesting aspect of the scheme is the use of mechanical contrivances for economizing in labour. *Fig.* 9 shows the Bucyrus Trench excavator, which was used on most of the sewer cuttings. Much of the ballast was obtained by means of the Bucyrus Drag Line Excavator, and on the Dorman Long houses use was made of the cement gun. Materials are brought to the site in trucks running on a narrow gauge railway, drawn by petrol engines.

The Fidler system is operated by The Composite Concrete Construction Co., of 11, Duke Street, St. James', which has been formed for the purpose. Mr. Fidler is himself responsible for the Hayes scheme. Mr. J. M. Wilson is resident Architect, and Mr. James Donaldson resident Accountant. The Contractors are Messrs. Sir Robert McAlpine & Sons, of 50, Pall Mall.

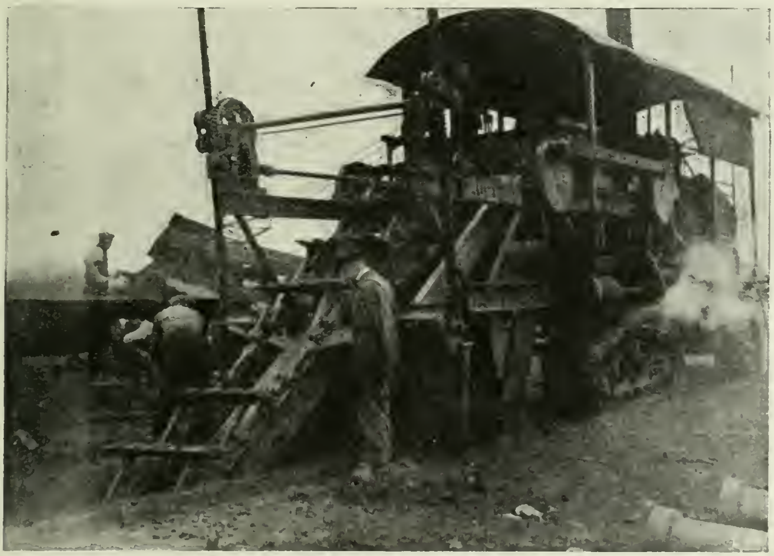


Fig. 9. Showing Bucyrus Trench Excavator at Work.
Hayes Housing Scheme.

MEMORANDUM.

Inquiry into the High Cost of Building.—Dr. Addison has appointed a Committee to inquire and report as to the reasons for the present high cost of building working-class dwellings and to make recommendations as to any practicable measures for reducing the cost. Mr. T. H. Sheepshanks of the Ministry of Health will act as Secretary to the Committee, and communications should be addressed to him at the Ministry of Health, Whitehall, S.W.1.

THE TREATMENT OF SMALL CONCRETE HOUSES.

By H. J. BIRNSTINGL, A.R.I.B.A.

(Continued from page 34. January.)

THE suitability of a building to its environment often becomes a matter of importance in designing a monolithic concrete house, because monolithic construction, more than any other form of concrete building, provides scope for special treatment. And in certain parts of the country, where the very ground, the trees, and the buildings seem to exude a spirit of slowly changing traditions, so that in contemplating the landscape an atmosphere of romantic and historical associations is created, it would be a veritable error of taste to erect a building whose form would be altogether inharmonious by reason of its novelty. In other districts, however, where this spirit of gentle maturity is not so manifest, a new architectural form might well afford no harsh contrast.

England, in common with other countries of the North, is pre-eminently a land of pitched roofs. The reasons for the prevalence of this form of covering are too well known to require comment. The pitched roof carries off the rain and the snow with greater speed than would a flat roof. Moreover, there is a difficulty in constructing a flat roof that shall be weather-proof without resorting to the employment of expensive materials. Concrete, however, not only provides a flat roof that can withstand rain and snow, but it is more suitably employed as a roof covering in this form than in any other (with the possible exception of the vault or dome), hence, it is not surprising to find that, in many instances, monolithic houses—and indeed concrete houses whose walls are built in other methods—have flat roofs. It is an easy matter to foresee the kind of surrounding that would be most suitable to the flat roof. In towns it is no rare thing to find that the roofs of many quite small houses are invisible where they are hid behind a blocking course; again, among pine woods or perhaps by the sea-shore, where the main lines of the landscape are horizontal, the flat-roofed house would not offend by contrast.

In the monolithic house the item of expense is the shuttering, and it will be difficult to provide any complexities and irregularities of outline, or any profusion of ornament. The charm of the design will depend upon bold simple lines; for the most part the horizontal will be emphasized rather than the vertical. Balance in the design will depend upon well-spaced and well-proportioned fenestration. The misplacing of a string-course is sufficient to spoil a simple wall by dividing the surface into ill-proportioned parts. The angles of a monolithic house can receive special emphasis at but little additional expense. Cornices will be simple with only a few members, but these must be carefully detailed. A concrete bungalow erected at Los Angeles, California, is illustrated in *Fig.* 1. There is a certain charm in the boldness and directness of this design that is extremely satisfactory. The lines are simple, yet sufficient. There is no attempt to disguise the material, or the method of using it. At the first fulgurant glance the design may shock, but it does so only because it contravenes the accepted traditional forms. In matters of architecture there is a fundamental tendency to admire those things which most nearly approximate to the expectations of the individual beholder. It is difficult to view a building dispassionately, because architecture, more than any other art, is intimately bound up with human life. But progress can only be achieved by means of courageous experiments, and associations must not be allowed to hamper abstract judgments.

A somewhat larger monolithic house is shown in *Fig. 2*. Here again the conspicuous feature is the simple massing. The interest in the design lies in the contrasts of light and shade. It is no exaggeration to say that in this building there exists a very real relationship between the design and the method of construction. There are no complexities of angles and differences in levels. The shuttering would be of the simplest, and the work would progress in level horizontal courses. The actual system employed on this house is that known as the Fellgren, which comprises a framework of grooved studding, to which the inner shuttering is attached. This studding is partly embedded in the concrete and partly projects, and to it the inner lining of lath and plaster is subsequently fixed. In this way the cavity is formed. It will be seen, then, from these two examples, that without straining for logical results, or the vindication of any abstract theories on design, the system of monolithic construction has its own definite characteristics.

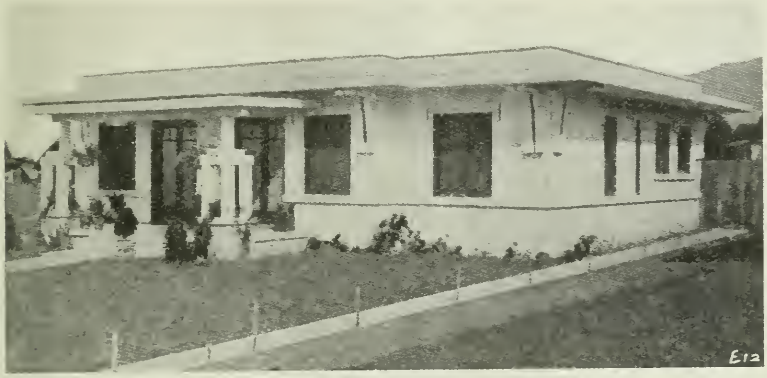


FIG. 1. CONCRETE BUNGALOW AT LOS ANGELES, CALIFORNIA.

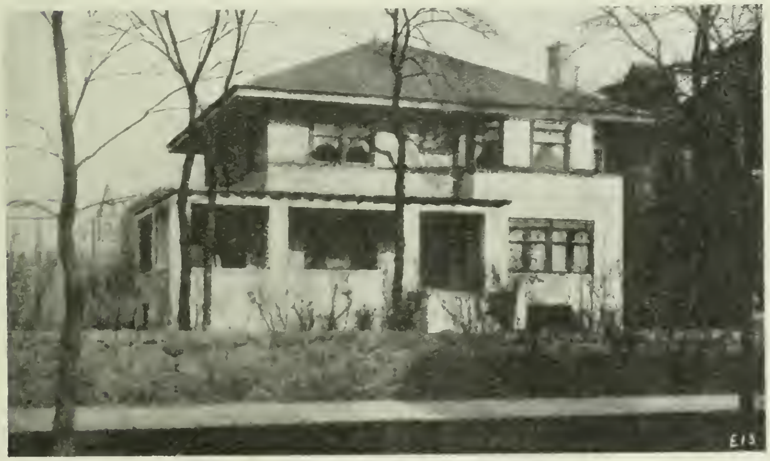


FIG. 2. MONOLITHIC CONCRETE RESIDENCE, CHICAGO.

In *Fig.* 3, however, is seen a monolithic house that breaks but little new ground. Concrete being unsuitable for fine detail work such as can only be achieved by the skill of the joiner or the mason, the cornice and doorway are in wood. There is ample enough precedent for the combination of brick and timber in 17th and 18th century work, and concrete and timber may well be combined for a similar reason. The unornamented chimney stacks show again that an endeavour would appear to have been made to simplify the shuttering to the utmost. This house is erected in America and is based on the " Colonial " tradition.

The Mansard roof has never found favour in England. It is difficult to account for the persistence of this prejudice, since as a roof form it has both economy and charm to recommend it. In France, Belgium, Germany, and Holland, it is employed extensively. *Fig.* 4 shows a monolithic concrete house with a Mansard roof. The main form of the house is kept simple and direct, the front wall is carried up to form the face of the dormers, nevertheless, although the design is delightful in itself, it does not emphasise the particular quality of the material in which it is built.

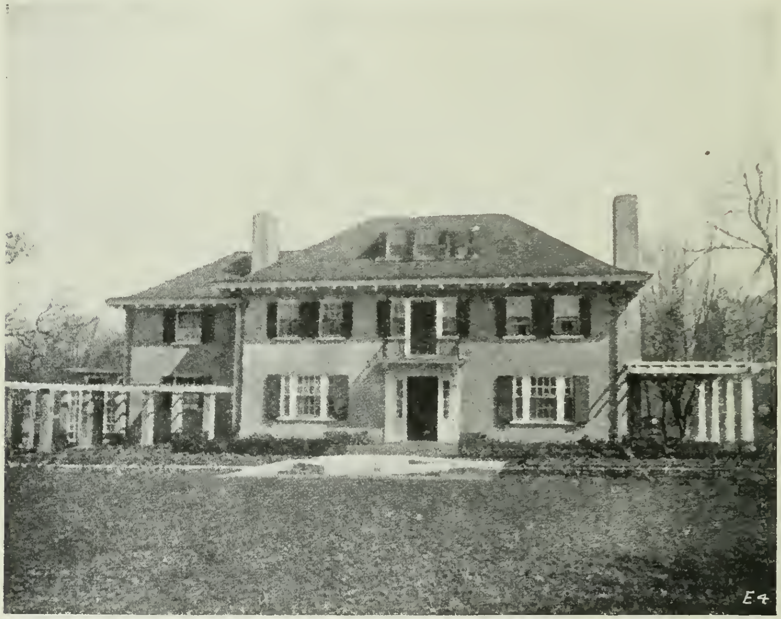


FIG. 3. MONOLITHIC HOUSE IN AMERICA.

The " gunite " house consists of a timber frame, a backing of Willesden canvas or some similar material, expanded metal lathing, and a covering of concrete applied under pressure by means of a cement gun. It will at once be appreciated that this system is therefore only suited to small buildings. The same necessity for simplicity in outline will not exist as maintains with the employment of shuttering. There is no inherent difficulty, and no great expense in framing or covering a building which may possess somewhat complex gable ends and dormers, so that it is legitimate to expect a more picturesque effect, due to a greater diversity of plane surfaces. *Fig.* 5 shows a small house built of timber covered with building paper, metal lathing, and concrete; actually this house is built around an old timber cottage which formed the nucleus for the larger building that is illustrated. Particularly characteristic of such materials is the treatment of the buttresses. By no other means would it be possible to form the battered surface with so little additional expense. This design, then, may be taken as an indication of the kind of treatment to which the material and the method of using it most easily adapts itself.

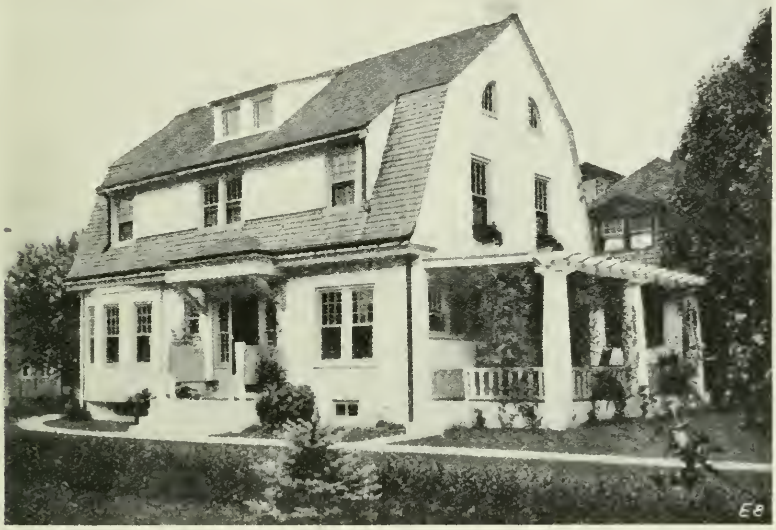


Fig. 4. Monolithic Concrete House in America.

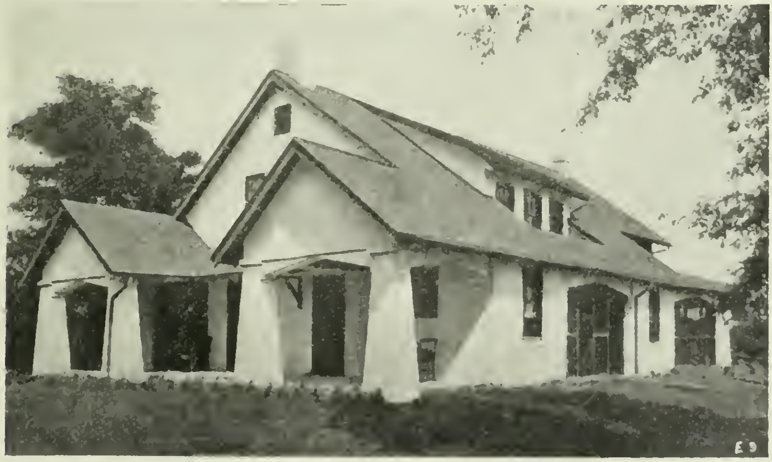


Fig. 5. Concrete House at Youngstown.

There is one important aspect of the subject to which, so far, but scant reference has been made. Texture and colour are as important considerations in concrete as in brick or stone, and, as in these materials, their quality will, for the most part, be governed by cost. In America the process known as aggregate exposing has been successfully developed. Various methods are used, such as scrubbing, brushing, or washing with dilute muriatic acid. The aggregates are very carefully selected and graded so that the desired colour may be obtained.

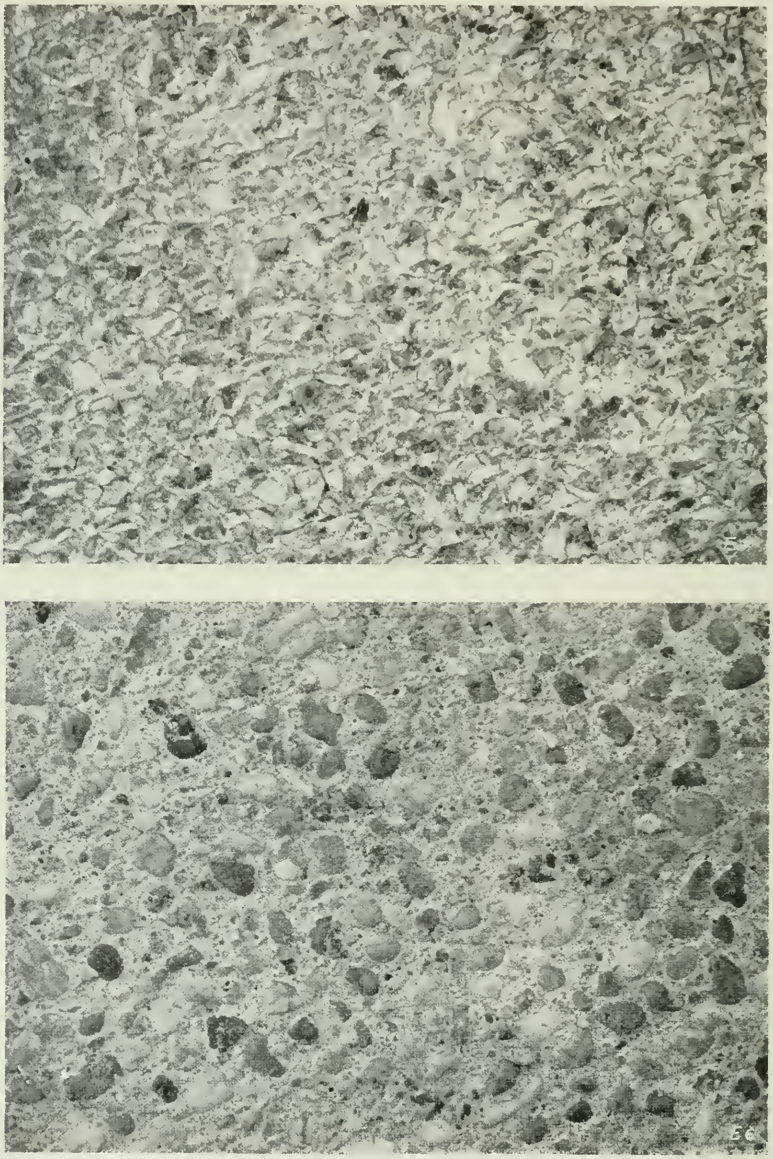


Fig. 6. Examples of Aggregate Exposing.

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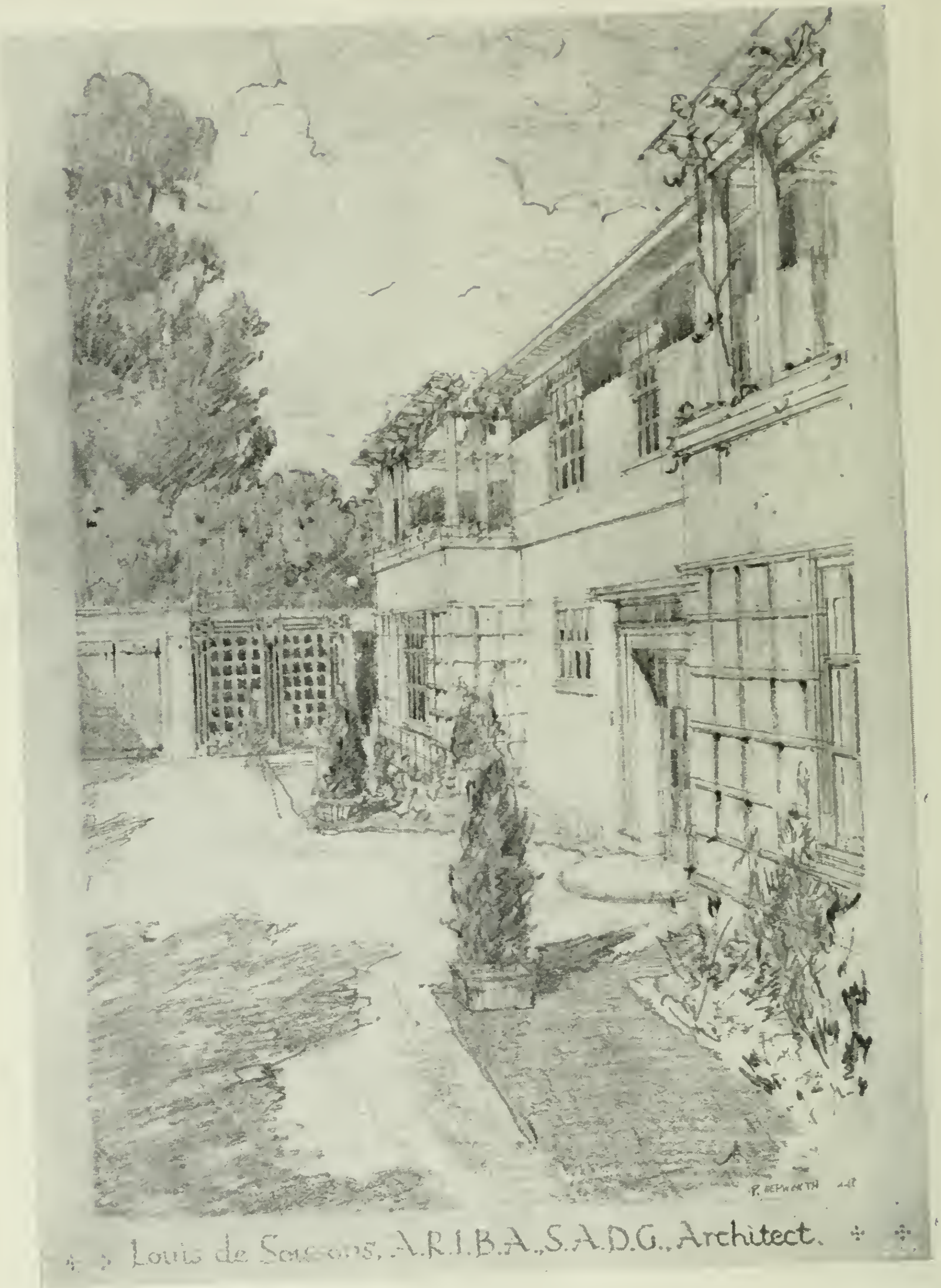

P. HEPWORTH
Louis de Soissons, A.R.I.B.A., S.A.D.G., Architect.

House at Welwyn Garden City on the "C.D.L." System.
(*For description see page* 118.)

Fig. 6 shows two examples of aggregate exposing. It would seem that there is a distinct opening for experimental work in England in connection with concrete surfaces. The usual practice seems to be, either to cement render or to rough cast where a protective coat is applied; a little enterprise might reveal other surface treatments that might not add materially to the cost of the building.

The various methods of construction, and the treatment which they suggest, can now, perhaps, be summarised. The block may be used in the same way as a poor quality brick; when it is so used the question of scale is of no importance, attempts should be made where circumstances permit to devise some more interesting protective coat than the ubiquitous rough cast. Where the block is not faced, care must be taken that it is not out of scale with the building. Here, too, a more interesting surface might well be obtained than that which is usually encountered. This will to some extent depend upon the aggregate and the method of employing it. The steel-framed house has very definite limitations, since the parts must be standardised and the outline kept as simple as possible. The monolithic house is probably the cheapest to erect where aggregate is obtainable on the site. The designer must always be mindful of the shuttering; he will therefore attempt to obtain his effects by large masses of voids and solids, and light and shade. The main lines will, for the most part, be horizontal; he must give particular consideration to the environment of his building. The flat roof should only be used with the greatest discrimination. With the gunite house there exist fewer restrictions of form and outline. There is considerable scope for buttressing and arching, for irregularity of outline, and it is possible to indulge in greater complications of surfaces. It might be said that the gunite house can be picturesque rather than dignified, although it should be remembered that picturesqueness is not in itself an architectural quality.

If, however, the best results are to be obtained from concrete, it is essential that architects, who are alive to the problems of the day, to its aspirations and its requirements, should interest themselves in the material. Without doubt many of the recently erected concrete dwellings are unsatisfactory because they are the work of men who are interested in concrete as a material, but who lack the necessary qualifications and training to enable them to produce a successful design. It is but to be expected that the architect should be able to appreciate the æsthetic possibilities of the material, which are indeed very real, and he will perhaps best achieve this by collaboration with those who have had actual first-hand experience with the material. Such a partnership should produce the good results which it is known can be obtained from concrete, but which are, nevertheless, so often lacking in contemporary work in England.

MEMORANDUM.

Birmingham Architectural Association.—At the fifth general meeting of the Birmingham Architectural Association, Professor F. C. Lea read a paper entitled "Reinforced Concrete," in which he said we were living in an age when labour and material were expensive, and one of the problems of the day was how to maintain economy of expenditure in buildings, not only with the highest degree of suitability to the particular purpose for which they were to be used, but also to obtain the best and most pleasing architectural effects. Reinforced concrete could no doubt be used to satisfy those aims, and architects, working with those who understood the constructive and scientific possibilities of this material, might use it to produce worthy structures.

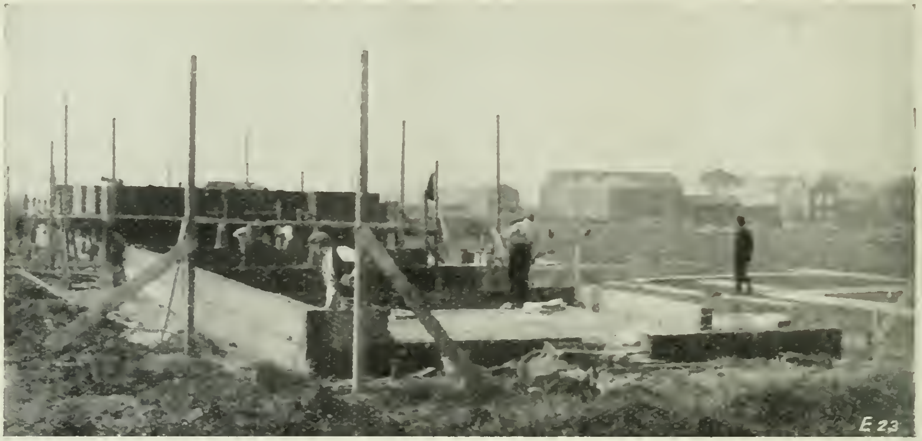


Fig. 3. This View shows the Raft of a "C.D.L." house, with the first course of the Walls. A part of the second course is seen on the left-hand side of the picture.

THE "C.D.L." SYSTEM OF CONCRETE CONSTRUCTION.

By the courtesy of Concrete Dwellings (Parent Company) Limited, of Westminster, we have been allowed to watch the operation of their "C.D.L." machine in the actual construction of dwelling-houses at Dailymail, a portion of the Welwyn Garden City Scheme.

Under this system of house-building, solid walls, or hollow walls with concrete ties, are constructed by means of a travelling mould shown in *Fig.* 2. If a hollow wall is to be built the mould is provided with a core; if a solid wall is desired, the core is absent.

In the case of the hollow wall, in order to form the concrete tie a piece is cut out of the core which is shaped as in the sketch *Fig.* 1. The result is that the concrete which fills the space so formed extends across the cavity and constitutes the tie which is monolithic with the inner and outer leaves of the wall.

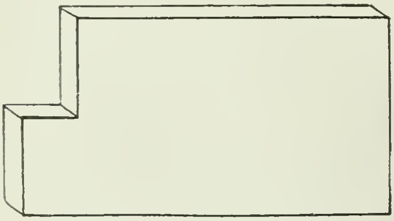


Fig. 1.

If desired, cavity walls with metal ties can also be constructed with this machine.

Foundation.—The method of construction is as follows: The footing to the walls is made in the usual way and, following accepted practice, is double the width of the walls themselves. The upper surface of the footing is left rough in order to provide a key for the first course.

Inside the footing a concrete raft, 6 in. thick, is laid in situ over the whole site. This is shown in *Fig.* 3.

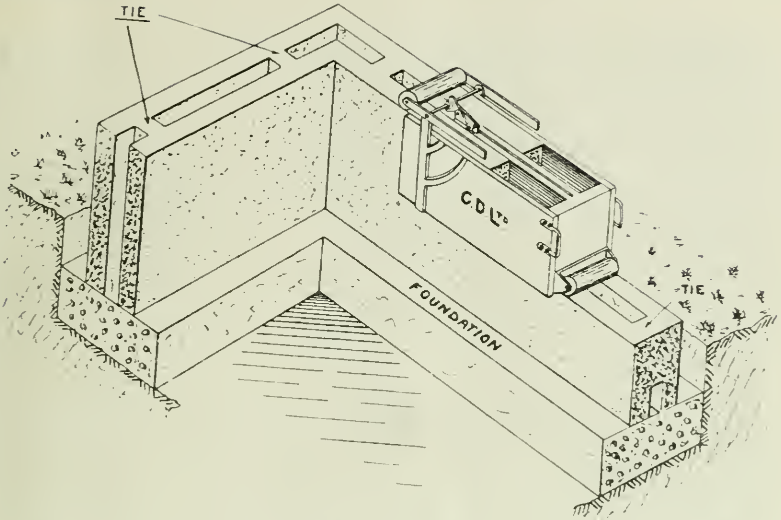


FIG. 2. ILLUSTRATING THE METHOD OF CONSTRUCTING A CAVITY WALL WITH THE "C.D.L." MACHINE.

THE WALLS.—The thickness suggested for cavity walls is 9 in., made up of two leaves each $3\frac{1}{4}$ in. with a $2\frac{1}{2}$ in. cavity between.

The mould is placed in position on the footing which has been previously marked out with builder's lines. It is then gradually filled with a semi-dry mixture, which is rammed continuously. During the ramming the sides and core are automatically held in position. As soon as the mould is full and the upper surface of the material trimmed, the sides are released by means of a patent expanding and contracting mechanism, and a well-rammed, semi-dry mixture having been used, the machine can then be moved forward, leaving

FIG. 4. "C.D.L." HOUSES UNDER CONSTRUCTION, SHOWING THE WALLS UP TO FIRST FLOOR LEVEL.

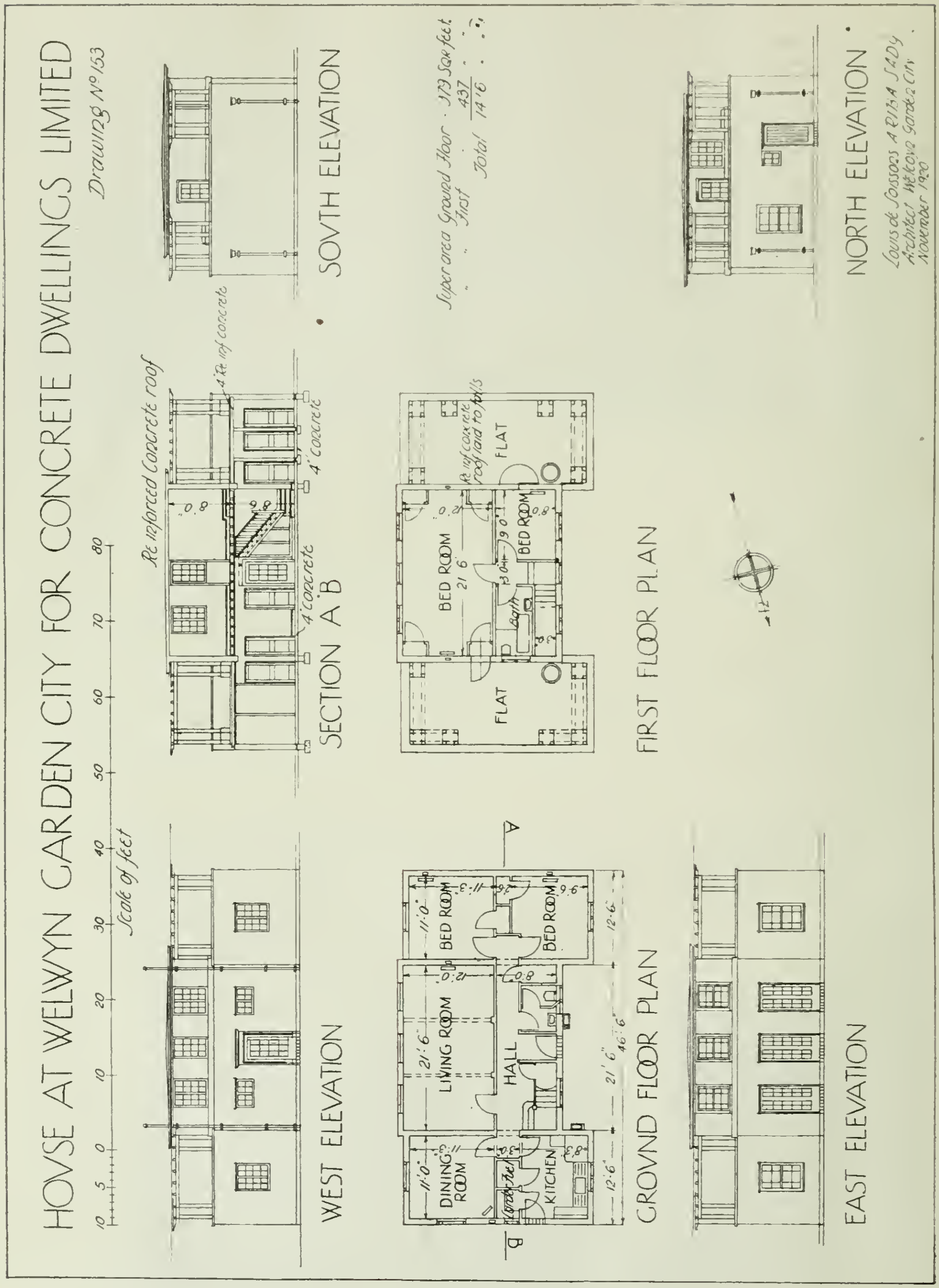


Fig. 4A. Details of House at Welwyn Garden City.

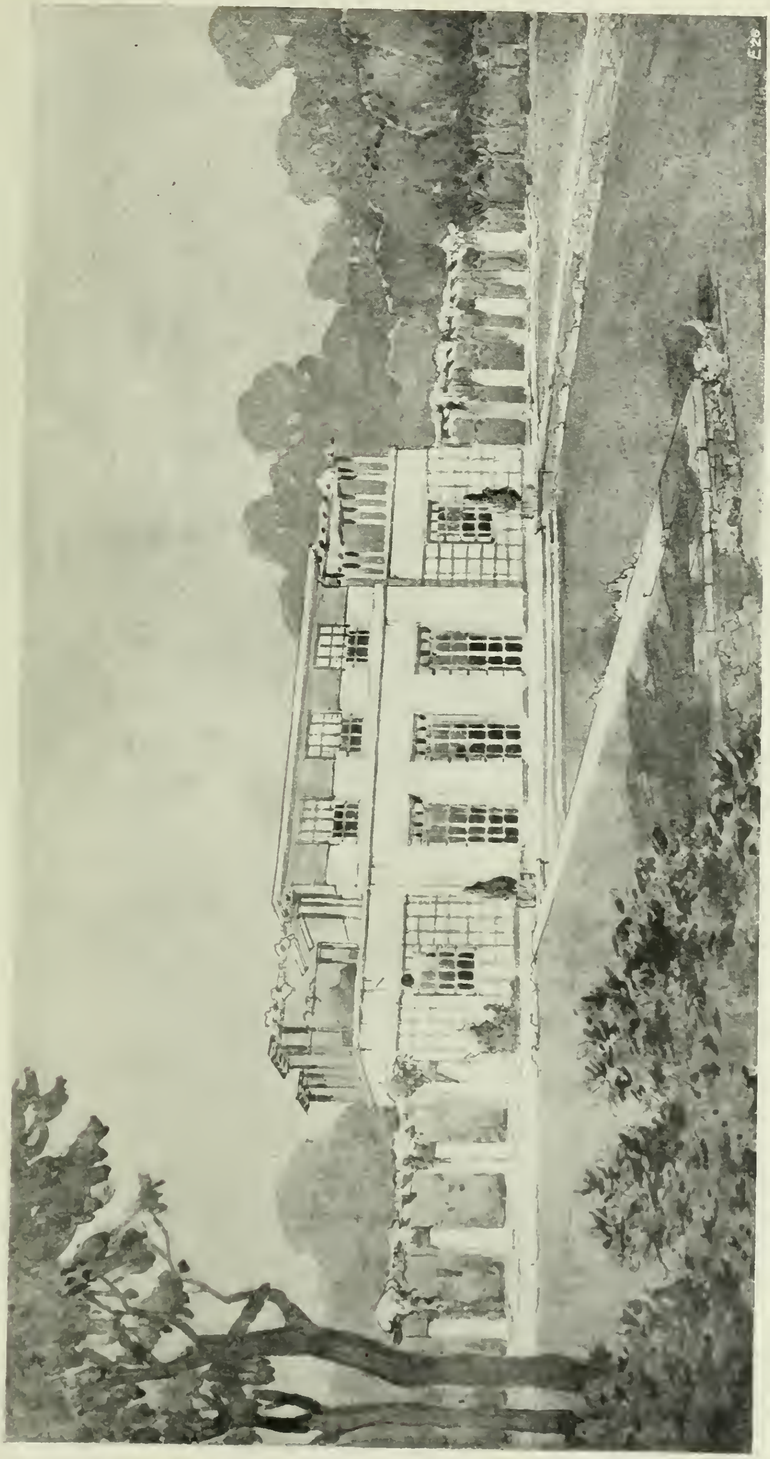


FIG. 5. BACK VIEW OF HOUSE AT WELWYN GARDEN CITY ON THE "C.D.L." SYSTEM.

behind it a section of wall the size of the mould. This process is repeated until the first course of all the walls is complete.

After twenty-four hours the machine may be placed on the top of the previously constructed work, which is well wetted and the next course laid. Thus, course by course, the wall is erected and forms a monolithic structure. The walls up to first floor level are seen in *Fig.* 4.

The moulding of the corners is an interesting operation. The corner of each course is formed by an **L**-shaped attachment, similar in other respects to the machine itself. This is first placed in position. Two machines are then attached, one at the end of each arm of the corner-piece. (In certain circumstances, one machine only is attached.) The corner is thus formed monolithically and without joint.

In order to ensure that the walls shall be absolutely plumb, the position of the mould is corrected for every section by means of a spirit level, it being obvious that if correct horizontally, the course will be correct vertically.

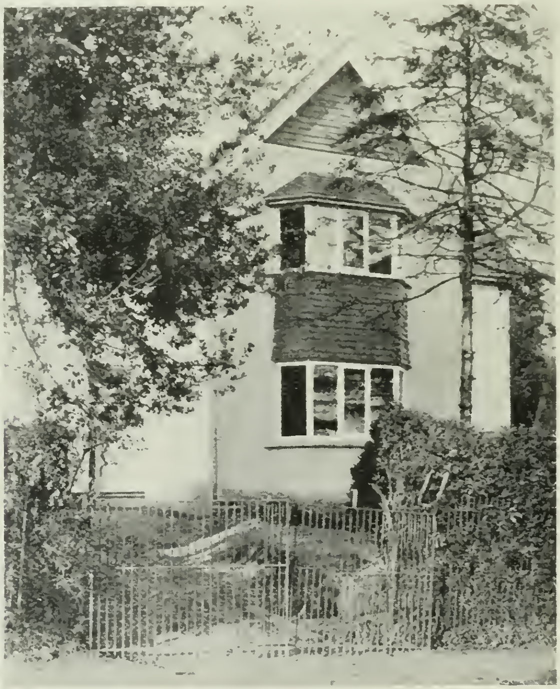


FIG. 6. VIEW OF A FINISHED HOUSE ON THE "C.D.L." SYSTEM.

If desired, different materials may be used for each leaf of a cavity wall, so that, say, gravel concrete may be employed for the outer leaf, and concrete having a porous aggregate for the inner, in order to overcome the condensation difficulty.

The partition walls are built on the same principle except that they are solid and 4½ in. thick.

Into the sides of doorways and window-openings strips of wood are cast in order to make provision for affixing the woodwork, and pre-cast reinforced concrete lintels are employed over doorways and window openings.

DAMP-COURSE.—For the damp-course, the provision of which is always advisable, any recognised material may be employed.

Roof.—In the case of the houses being erected on this system at Welwyn the roof is to consist of two layers of pre-cast concrete slabs arranged with a cavity between them, and the joists also will be of reinforced concrete.

Material.—Local gravel, excavated on the site, is employed as the aggregate. This is screened and re-mixed in the proportion of 1 : 2 : 4, the coarse material not exceeding $\frac{3}{4}$ in. in diameter.

Surface Treatment.—It is proposed to rough-cast the walls externally and coat them internally with lime plaster.

General.—This system, like many other concrete systems, will provide another avenue for the employment of ex-service men. On the two houses being erected at Welwyn, all the men employed except the foreman are unskilled.

The Company do not propose to undertake concrete work themselves, the intention being to work on licence through builders and contractors. Any builder who adopts this system will be supplied by the Company with a trained man who will instruct the builder's own workmen.

The system, which has been approved by the Ministry of Health, is patented in all countries, and actual work is being carried out in France, Italy, Belgium and India in addition to the United Kingdom.

The specific claims made for this system are: No expensive machines necessary. No previous moulding of blocks. No storage. No multiple handling. No block-setting. No grouting, since everything is done in one operation, and, since one course is laid daily, rapidity of construction is ensured.

In the case of one house, nine men working seven hours a day erected the walls up to roof level in ten days.

The Architect for the Welwyn Garden City scheme is Mr. Louis de Soissons, A.R.I.B.A. At the time of going to press these houses were unfinished, but the artistic appearance which it is anticipated they will present is indicated by the drawings which are reproduced in the frontispiece and in *Fig.* 5. *Figs.* 6 and 7 are photographs of two other houses erected on the "C.D.L." system.

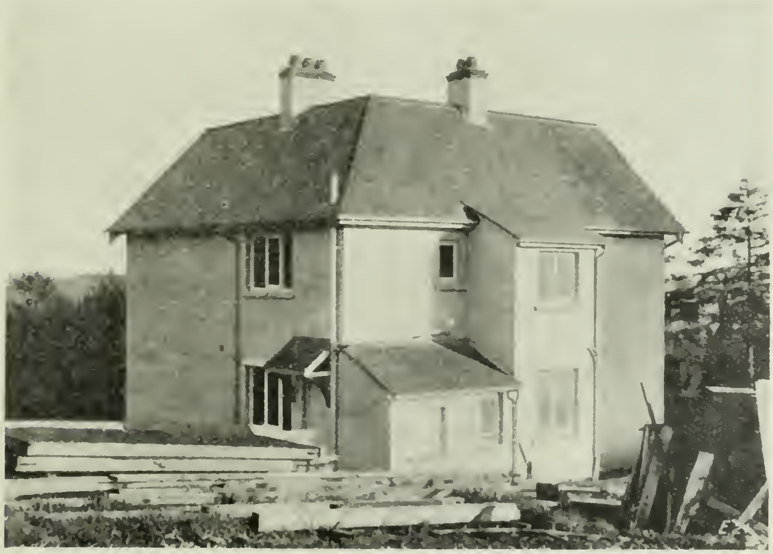


Fig. 7. Back View of a Finished House on the "C.D.L." System.

CONCRETE ROADS FOR WORKS AND FACTORIES.

It is fast becoming a recognised fact that concrete forms an ideal road surface for the many roads and driveways leading to large works and factories, in view of the heavy and continued traffic passing over them, and in the last few years a large number of our industrial firms have adopted concrete for this purpose.

In the United States this form of construction has been even more widely used, but an interesting development in this direction is the adoption of such roads for the large oil refineries and distributing stations in America. In this instance owners had to consider the effect on the concrete of the oil drippings which it was feared might make the roads slippery and perhaps cause deterioration of the concrete. Experience has, however, shown that these fears were groundless, and our readers may be interested in the following particulars and illustrations taken from the *Concrete Highway Magazine*, giving a short account of what has been the experience of some of the American Oil Companies.

" At many oil refineries and retail and wholesale oil distributing stations, the common driveway and teamyard paving problems are being successfully solved by the use of concrete. The service required of concrete pavements by the oil industry is somewhat more exacting than in many other lines of manufacture. The traffic loads are frequently excessive and the surface must be able to resist the action of oil drippings without becoming slippery.

"The general practice in the design and construction of concrete pavements for driveways of this character has followed somewhat closely the developments of concrete highway pavement construction. In the early stages of the expansion of the oil industry and before the adoption of motorised distributing units it was often thought sufficient to lay a surface of oil or asphalt-bound macadam or gravel. This type of surfacing was soon found inadequate for the requirements, and so the construction engineers of this industry turned to concrete.

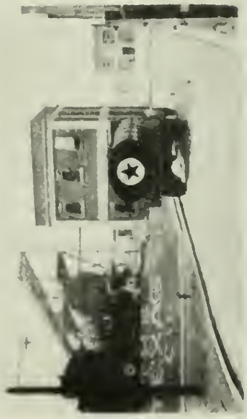
"Their first concrete driveways were not always successful, because it was thought the design and methods of ordinary concrete sidewalk construction would be ample. However, with the increase in weight of motorised tank trucks it was soon found that the principles of standard concrete pavement construction must be followed. Present specifications for concrete driveways used by the oil industry follow closely the recognised features of the best highway construction as to thickness, reinforcement, mixtures, cleanness of materials, and finishing and curing methods.

"The surface finish and wearing qualities of concrete pavements at retail gasoline stations are especially important. It is necessary to produce a surface

Mexican Petroleum Co., South Portland, Maine

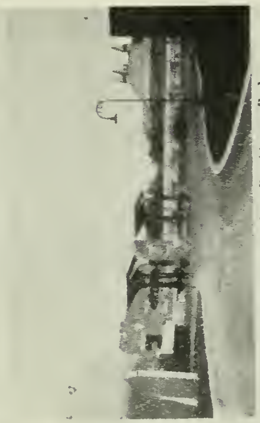
Shell Oil Co., Seattle, Wash.

Standard Oil Co., Chicago



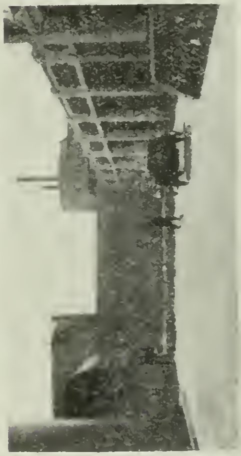
The Texas Co., Long Island City, N. Y.

Gasoline Consumers Association, New Castle, Pa.



Atlantic Refining Co., Providence, R. I.

Standard Oil Co., Tacoma, Wash.



Tidewater Oil Co., Yonkers, N. Y.

Standard Oil Co., Kansas City, Mo.

Concrete Roads at American Oil Refineries.

which can be quickly cleaned by flushing with a hose-stream and from which the snow can be easily shovelled in winter. The attendants at these stations cannot allow snow to accumulate, but must clean it away frequently during the course of a storm. This makes it important that the surface offer minimum resistance to shovelling or sweeping. The surface must be sloped on true lines so that water will drain away quickly. To meet these requirements the surface is usually trowelled more carefully than is the case on street or road pavements.

"The typical oil plant or refinery is marked by neat buildings, well-arranged yards, and concrete pavements. An interesting example is found at the Long Island City, N.Y., plant of the Texas Co., which produces the "Texaco" line of petroleums and asphalts. At this plant some 3,900 square yards of concrete pavements have been completed.

"The Standard Oil Co. of New Jersey has nearly 30,000 square yards of concrete drives at three stations in Massachusetts and Rhode Island.

"Many retail stations of the various Standard Oil Companies scattered from coast to coast are distinguished for convenience and appearance because of the excellent concrete pavements which have been provided. Among other firms which are rapidly improving wholesale and retail distribution plants with concrete are the Union Oil Co. of California, the Shell Oil Co., the Pure Oil Co., the Continental Oil Co., and the Sinclair Refining Co.

"The accompanying illustrations show how concrete pavements serve the oil industry from coast to coast."

MEMORANDUM.

A New Stretch of Concrete Highway in British Columbia.—Towards the end of December a length of concrete road, which is to form part of the Great Pacific Highway from Vancouver to Mexico, was thrown open to traffic. The work had been carried out by the Ministry of Public Works, Victoria. This particular stretch brings the junction of the Yale and Johnston Roads within an easy distance of the Royal City Post Office.

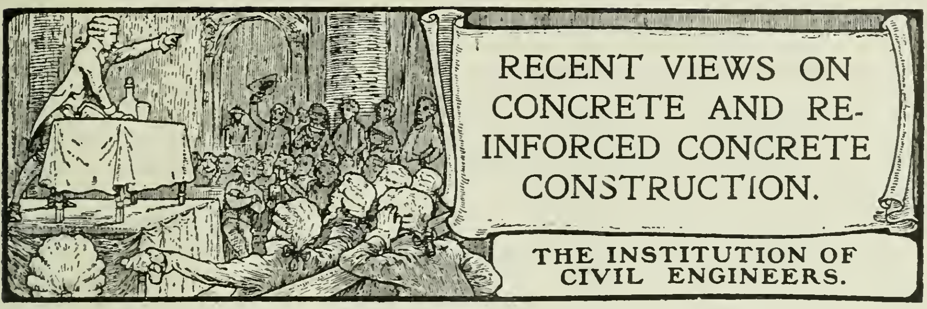
At the opening ceremony, emphasis was laid upon completing the road as far as Blaine, so that Canada might be represented with a fully paved section of the great highway stretching from Vancouver to Mexico.

Mr. Foreman, President of the Canadian Good Roads Association, and formerly engineer of the Public Works Department at Victoria, stated that as a section of the Transprovincial Highway, as well as of the Pacific Highway, the road just declared opened was destined to be a link in the great Dominion highway stretching from Halifax to the Pacific coast, which the Canadian Good Roads Association was devoting its energies to promote. It was announced that an early start would be made on the last remaining important link in the Transprovincial Highway, i.e. from Hope to the system of roads in the dry belt.

Those inspecting the length of road thrown open to traffic were impressed with the excellent quality of the pavement, which is of the same substantial type of concrete as British Columbia motorists are familiar with in stretches of the Pacific Highway in the State of Washington.

The pavement is wide enough for two cars to pass abreast, and has a gravel fill extending on each side to a width of four feet.

An awkward hill which existed on this stretch of road had been graded so effectively as to enable drivers now to take it with great ease.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE CONSTRUCTION.

THE INSTITUTION OF CIVIL ENGINEERS.

"REINFORCED CONCRETE FOR SHIP CONSTRUCTION."

By Professor THOMAS BERTRAND ABELL, O.B.E., M.Eng.

The following is a short abstract from a paper read before the above Institution on January 11th.

THE paper places on record particulars of tests on and the general experience gained with concrete and reinforced concrete used in the construction of concrete sea-going vessels designed and built under the direction, first of the Admiralty and, subsequently, of the Controller General of Merchant Shipbuilding during the years 1917 and 1918.

Crushing tests carried out on the concrete with various types of aggregate are summarised. The concrete was of a rich mixture varying from one part of cement with 2·67 parts of mixed aggregate, to one part of cement with 3·66 parts of mixed aggregate. The aggregate consisted of natural gravel or crushed stone passing through $\frac{3}{8}$-inch square or $\frac{1}{2}$-inch round holes. The crushing tests show a wide variation in strength. It became clear there was no disadvantage in using a well-rounded smooth beach-gravel as aggregate. Better results were obtained with such an aggregate than with an angular aggregate. Good grading of the aggregate, together with extra fine grinding of the cement, were always found advantageous.

Density of concrete is important for ship construction, since the weight of the ship without cargo is an important factor in determining the dimensions of the ship. The extreme variation in weight per cubic foot amounted to 10 lb., involving nearly 7 per cent. variation in the weight of the hull structure.

Bending tests were conducted on reinforced concrete beams to determine

(1) The value of concrete under tension ;

(2) The comparative value of round bars and different types of wire rope for reinforcement ;

(3) The behaviour of concrete under alternating stress :

- (*a*) At a stress less than that corresponding to rupture under tension ;
- (*b*) At a stress greater than that corresponding to rupture under tension.

Particulars of the beams used and the curves of deflection and load are given.

The beams for the alternating tests consisted of hollow cantilevers of rectangular cross section erected vertically. Their lower ends were fixed in the ground, and the upper ends were subjected to an alternating force having a frequency of 4 to 7 (complete reversals) per minute. The calculated stresses in the concrete during the experiments were 180 lb. and 360 lb. per square inch. The cantilevers were filled with water so that evidence would be forthcoming directly the concrete on the tension side was completely fractured. Cracks were produced after a time with the tensile stress as low as 180 lb. per square inch.

The noteworthy feature about the tests was the eventual sealing of cracks through which water had been percolating. Whether the sealing was due to further hydration of the cement after grinding under the alternate opening and closing of the crack was not determined, but the cracks remained tight and were only reopened on increasing the load.

The total number of reversals was 200,000 on one beam and 100,000 on a second.

Further tests were made to determine whether concrete could be placed on a practical scale in thin slabs so as to act as a container for heavy oil fuel of high flash-point, and also for petrol. There was no difficulty in regard to the heavy oil, and though with extreme care concrete containers might have been made to retain petrol, it was decided that the risk would be far too great to enable petrol to be carried in bulk in a ship.

The remaining tests relate to experiments carried out to determine the permeability of concrete, the means of protecting reinforced concrete from the corrosive action of salt water and from the disintegrating effect of vegetable lubricating-oils on the interiors of the self-propelled vessels.

It was found that without any surface treatment 2-inch slabs of concrete, cast with their faces vertically, would frequently resist water pressure of 200 lb. per square inch. It was concluded that it was unnecessary to use any water-proofing compound, and that the richness of the concrete, together with the grading of the aggregate, were sufficient to guarantee watertightness.

The paper contains several diagrams and an appendix giving particulars of the tests.

MEMORANDA.

The South Wales Institute of Engineers.—An interesting paper was read before the above Institute on December 16 last on the Application of Cementation to Mining. Owing to lack of space we have had to hold over an abstract from this paper until our March number.

Shipbuilding.—A concrete motor vessel has been built at North Sydney, in Nova Scotia. It is 127 ft. in length, 27 ft. in beam, with a depth of 12½ ft., the net register being 282 tons. A 240 h.p. Bolinder oil engine is installed. This vessel is to be employed in the Sydney-Newfoundland trade.

A Finish to Concrete Floors.—In a recent issue of our contemporary, *Concrete, U.S.A.*, it is stated that in a number of concrete houses that are being built all the floors are concrete, and in order to overcome the objection usually made to concrete floors in dwelling-houses, these floors were brushed over with common brown creosote stain, and when this was dry they were given a generous application of floor-wax. This was rubbed and the floors have a smooth wax finish, and give an appearance of warmth. They are easily kept clean.

A Floor Test.—In view of the article published in another part of this issue dealing with the flat slab system of construction, it is interesting to note a test on a floor built on this system recently at the Garston Match Factory, Liverpool, for Messrs. Maguire, Paterson & Palmer, Ltd. The spans between the columns are 20 ft. and the diameter of the columns is 20 in. The floor was designed to carry 3 cwt. per ft. super and was submitted to a test load of 4 cwt. per ft. super.

The Architects for the building are Messrs. Mewes & Davis, the reinforced concrete was designed by Mr. S. Bylander, and the constructional work was executed by Messrs. F. D. Huntingdon, Ltd.

Reinforced Concrete Design.—In a recent lecture before the Department of Engineering, Johns Hopkins University, Baltimore, Mr. Ernest P. Goodrich, of New York City, said that thus far throughout the history of reinforced concrete the general tendency had been to force that material into forms both structural and architectural which were like those to which engineers and architects and the general public had heretofore been accustomed, such as timber beams and columns, stone quoins, lintels and sills. Obviously, however, reinforced concrete was inherently different from those materials, and the highest art should and would doubtless eventually develop designs for structures and façades which belonged as intimately to reinforced concrete as did the forms above mentioned to structures now made of separate members. In spite of the rapid advancement which had been made in the last decade in the field of use of reinforced concrete, and the designs of structures employing it, it was believed that the possibilities of the field had not begun to be exhausted, nor had the end been reached in the devising of improved methods for the handling of materials, the manufacture, erection and rehandling of forms, the surface treatment of exposed work or the reductions in cost which might be effected by saving material through more detailed studies of secondary stresses and the methods of best providing them.

CONCRETE IN THEORY AND PRACTICE.

A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.

REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—Ed.

CHAPTER V.

Design of Columns.

69. It has already been explained how columns may be designed to carry definite loads centrally or axially applied.

It has also been explained that in practice it is practically impossible to secure axial loading. Perhaps the reason for this is worth recapitulating. When a beam is built monolithic with a column at each end, and loaded, it necessarily deflects, so that the end now takes up a slope if it were originally horizontal. The effect is that either the beam rests on the inside edge of the column, or else the column bends so that its upper end takes up the same slope as the end of the beam. In either case, the column is subjected to a bending moment in addition to the direct load.

Now the amount of the bending moment depends on the relative stiffness of the beam and the column.

If the column is very stiff compared to the beam, it will offer great restraint to the end of the beam, and will approximate to the case of a beam fixed in direction at the ends, for which the bending moment is $\frac{Wl}{12}$ at the ends.

If the column is very flexible compared to the beam, it will offer very little restraint, and the bending moment at the joint will approximate to zero. Practical cases lie between these limits.

Now a convenient measure of the relative stiffness of column to beam is the quantity $\frac{KC}{B}$ which may be written—

K = a constant depending on the fixity at the lower end of the column, and may be taken as 6 for outside columns and 4 for interior columns.

C = the moment of inertia of the column divided by its length.

B = the moment of inertia of the beam divided by its length.

TABLE I.

PROPERTIES OF STANDARD SQUARE COLUMNS.

Size.	Vertical Rods.	Equivalent Area. Concrete Units.	Moment of Inertia. Concrete Units.	Radius of Gyration.
In.	Diam.	Square In.	In.^{4}	In.
6 × 6	4—½ in.	47	119	1·58
8 × 8	4—½ ,,	75	385	2·26
10 × 10	4—⅝ ,,	117	992	2·91
12 × 12	4—¾ ,,	169	2,135	3·56
14 × 14	4—⅞ ,,	230	3,940	4·14
16 × 16	4—1 ,,	300	7,090	4·86
18 × 18	8—¾ ,,	373	10,510	5·3
20 × 20	8—⅞ ,,	467	16,540	5·94
22 × 22	8—1 ,,	572	24,920	6·59
24 × 24	8—1 ,,	664	34,000	7·14

Note.—This table does not allow for neglecting 1½ in. of cover, as suggested in L.C.C. regulations.

Now in the table in par. 50 the moment of inertia of the author's series of standard beams was given.

In Table I. it is also given for the author's standard square columns.

With these tables before us, it is therefore quite easy to calculate $\frac{KC}{B}$ for any given case.

Suppose, for example, we have a beam 25 ft. span carrying 25,000 lb. distributed load, supported on columns 12 ft. 0 in. long in the upper storey.

We shall find that our standard T beam 20 in. × 8 in. will be required, as explained in Chapter III. and our table gives the moment of inertia of this beam as 10,300, whence

$$B = \frac{10{,}300}{300 \text{ in.}} = 3{,}433,$$

300 being the length in inches (25 feet).

Suppose we support this on columns 16 in. × 16 in., we find from Table I. that the moment of inertia is 7,090, whence

$$C = \frac{7{,}090}{150} = 4{,}700,$$

150 being the length in inches (12 ft. 6 in.).

Taking K as 6 for outside columns, we have

$$\frac{KC}{B} = \frac{6 \times 4{,}700}{3{,}433} = 8{\cdot}2.$$

TABLE II.

BENDING MOMENTS IN OUTSIDE COLUMNS.

$\frac{KC}{B}$	Bending Moment.	
0	0	0
·1	$\frac{Wl}{333}$	·003 Wl
·2	$\frac{Wl}{174}$	·0057 Wl
·5	$\frac{Wl}{76{\cdot}5}$	·0131 Wl
1·0	$\frac{Wl}{42{\cdot}7}$	·0234 Wl
2	$\frac{Wl}{27{\cdot}5}$	·0365 Wl
5	$\frac{Wl}{18}$	·055 Wl
10	$\frac{Wl}{14{\cdot}9}$	·067 Wl
20	$\frac{Wl}{13{\cdot}3}$	·075 Wl
30	$\frac{Wl}{12{\cdot}8}$	·078 Wl
∞	$\frac{Wl}{12}$	·08$\dot{3}$ Wl

Note.—For outside columns K = 6 generally.

Tables II. and III. give the bending moments in the column for various ratios of $\frac{KC}{B}$, and from Table I. it will be seen that the bending moment corresponding to $\frac{KC}{B} = 8{\cdot}2$ is about $\frac{Wl}{16}$, which in our case is

$$= \frac{25{,}000 \text{ lb.} \times 300 \text{ in.}}{16}$$
$$= 470{,}000 \text{ in. lb.}$$

TABLE III.

BENDING MOMENTS IN INTERIOR COLUMNS.

$\frac{KC}{B}$	Bending Moment.	
0	0	0
·1	$\frac{Wl}{480}$	·00208 Wl
·2	$\frac{Wl}{250}$	·004 Wl
·5	$\frac{Wl}{117}$	·00933 Wl
1·0	$\frac{Wl}{60}$	·0167 Wl
2	$\frac{Wl}{36}$	·0278 Wl
5	$\frac{Wl}{21{\cdot}6}$	·0462 Wl
10	$\frac{Wl}{16{\cdot}8}$	·0595 Wl
20	$\frac{Wl}{14{\cdot}5}$	·069 Wl
30	$\frac{Wl}{13{\cdot}8}$	·0725 Wl
∞	$\frac{Wl}{12}$	·083 Wl

Note.—For interior columns K = 4 generally.

The stress in the column due to bending is given by

$$\frac{My}{I}$$

where M is the moment,
y is half the thickness of column,
I is the moment of inertia,

or, in our case,

$$= \frac{470{,}000 \times 8 \text{ in.}}{7{,}090}$$
$$= 530 \text{ lb./in.}^2$$

The direct stress due to the load is

$$\frac{12{,}500}{300} = 41\tfrac{1}{2}$$

$$\text{Total} \quad 571\tfrac{1}{2}$$

300 in the above calculation being the equivalent area of the concrete, as given in Table I.

There are good reasons for thinking that when the stress is calculated in this way much higher figures than 600 lb./in.^{2} are justified, though in the example given we have kept them under this figure.

(*To be continued.*)

CEMENT NOTES.

By Our Special Contributor.

Storage of Cement.

In the July issue of this Journal a summary was given of a report from the Structural Materials Laboratory of Chicago, upon the effect of storage of cement, the concluding paragraph of which stated that there is reason to believe that cement may be stored in bulk for long periods without materially affecting its concrete and mortar making qualities. Some tests that were recently made in this country give a striking support to this belief.

A consignment of about 300 tons of cement was stored in bulk in a shed on the East coast for three years and when examined at the end of that period it was found that a crust about 3 in. in thickness had formed upon the surface; when this crust was removed, the remainder of the cement was found to be of excellent quality as shown by the following tests:—

Residue on 180 sieve .	11·5 %
Initial Set	85 minutes
Final Set	283 ,,
Le Chatelier Test . .	nil

Tensile Strength—7 days neat 688 lb. per sq. in.

Tensile Strength—7 days 3 sand 1 cement—280 lb. per sq. in.

These results suggest that if at any time it is impossible to avoid the storage of cement, it is far better to store it in bulk than to attempt to keep it in sacks.

The Value of the Brand in the Portland Cement Industry.

In the latter half of the nineteenth century, the distinctions between the various brands of Portland Cement were more marked than they are in these days of standard specifications, and the practice of specifying certain brands was somewhat widely adopted by engineers and architects.

There were good reasons for this practice because the manufacture of cement was practically in its infancy and the differences in quality between one brand and another were appreciable.

The reputations for reliable quality established by certain manufacturers last century are still effective at the present day, and, on the other hand, the prejudice against cement made in certain districts—arising from attempts to produce cement with inadequate plant—has not yet died out, although there now remains no justification whatever for such prejudice.

It is undeniable, however, that strong preferences and strong antipathies in connection with certain brands of Portland Cement still exist, and a consideration of the causes for these may be enlightening.

It may be taken for granted that all Portland Cement produced in this country complies with the British Standard Specification, and the popularity enjoyed by some brands of cement must be due either to superlative quality as judged by British Standard Specification tests or to some other cause not revealed by such tests.

Firstly, with regard to the standard tests, it is evident that the quality appealing to users would be tensile strength above the average, resulting in a correspondingly stronger concrete. Fineness of grinding has no intrinsic value in itself, but is merely a means of obtaining additional strength, although to a contractor who buys cement by weight and uses it by measure, the extra bulk of finely ground cement is an attraction from a commercial standpoint. A cement therefore that consistently shows tensile strengths of 800 lb. when neat and 350 lb. when mixed with three parts of sand and tested at seven days would certainly be preferred to one that yielded say 500 lb. and 220 lb. respectively under the same conditions. Hence, the cement manufacturer has one very obvious method of improving the reputation of his brand by improving his tensile tests. By what means this can be done is not within the scope of this article to discuss.

Specification tests do not, however, reveal the secret of the popularity enjoyed by some brands because the popularity depends upon the faculty of rapid hardening, and it should here be explained that quick setting and rapid hardening are terms which when used in connection with Portland Cement have different meanings.

A " quick-setting " cement is one which reaches a certain arbitrary standard of consistency in less than thirty minutes, and the term has no reference whatever to the hardness attained in twelve or twenty-four hours. The term " rapid hardening " refers to the behaviour of the cement in the period immediately following the final set.

It is not uncommon to find that a cement with a final set of four hours is harder at twenty-four hours than one with a final set of twenty minutes, while at seven days the tensile strengths of the respective cements may be equal.

The quality of rapid hardening is particularly acceptable to the cement user—it enables him to proceed with his work at high speed because in eighteen or twenty-four hours his concrete is strong enough to bear the weight of superincumbent material—it reduces the amount of shuttering required, and it produces a concrete or mortar that is less liable to damage by frost, sun and wind.

Tests for rapid hardening are indeed the only tests applied to cement by the " man in the street " or his technical relative, the navvy, and a concrete that will bear his weight " the next morning " earns his commendation and stamps the cement in his mind as satisfactory.

Many manufacturers are entirely indebted to Nature for this desirable feature of their cement, because it is due to certain characteristics of the raw materials used in its manufacture, but there is hope that scientific research may be able to point the way to a general improvement in this respect which will be applicable to all cements.

The conclusion is thus reached that although the British Standard Specification has been instrumental in levelling up the quality of cement produced throughout the United Kingdom, there is still justification for preferences in connection with brands of Portland Cement.

So far as the export trade in cement is concerned, the brand is of great importance. In many countries there is no standard specification and facilities for cement testing are almost non-existent, so that the cement user has only the brand to guide him as to the quality of the material he buys. It is in such cases as these that the reputations for good quality established by some manufacturers last century and steadily maintained since, have been of benefit not only to the manufacturer but also to the user abroad.

Doubtful Aggregates.

There are certain materials which, considered as concrete aggregates, must be classed as doubtful, because although they may yield excellent results in nineteen cases out of twenty, or even ninety-nine cases out of a hundred, there occur instances here and there of failures which never happen when broken stone or clean gravel are used. Such doubtful aggregates are Blast Furnace Slag, Coke Breeze, Destructor Refuse, and Broken Brick.

If the question be asked concerning any of these, whether their embodiment in concrete is safe, the answer must be in the negative, but qualified with the statement that many have taken the risk of using them and are none the worse. It may be interesting to set out the nature of the risk with each of the materials mentioned.

With Blast Furnace Slag the danger lies in the presence of sulphur which may exist as sulphide of calcium or iron and sulphate of lime. When present as sulphide there is liability to oxidation with consequent expansion, and there is the possibility that the concrete will have the unpleasant odour associated with sulphuretted hydrogen, and also a greenish hue. Further, when used in connection with reinforced concrete there is a tendency to promote the rusting and expansion of the steel work.

When sulphate of lime is present in slag, the tendency of the sulphide to oxidise is implied and there is also the possibility of the sulphate of lime retarding the setting of the cement. Chemical analysis is sometimes resorted to in an attempt to decide the character of slag, but although a slag containing 2 per cent. or more of sulphate of lime might be condemned, it is impossible to base on chemical analysis a statement that any particular slag is perfectly safe for use.

With Coke Breeze, the danger also lies in the presence of sulphur, but as Breeze concrete is seldom used for any work of an important nature, expansion short of disintegration may go unnoticed.

Destructor Refuse may on occasion

be a curious conglomeration, and it is hardly possible to classify the risks which are possible with Destructor Refuse. Any uncalcined material of an organic nature may, of course, be dangerous.

With Broken Brick the presence of adherent lime mortar or plaster can be detected with the eye and such impurities constitute obvious risk. In the absence of this, however, there is still the possibility that the brick may contain sulphur compounds usually derived from the presence of pyrites in the clay from which the bricks were produced. Certain bricks from the Eastern Counties are notoriously unsafe for use in concrete on account of their sulphur content, but in the case of bricks, a chemical analysis will generally suffice to show whether the material is safe to use.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Reminiscences of a Municipal Engineer. By H. Percy Boulnois, M.Inst.C.E.
St. Bride's Press, Ltd.

The reader who has not had the privilege—and it is a privilege—of the personal acquaintance of Mr. H. Percy Boulnois, may be forgiven if, on seeing the title of this work, he passes it by as being of little interest to him. Should he do so, the loss will undoubtedly be his, since the book is of an uncommon type, full of human interest, and the reader, being taken behind the scenes, is afforded intimate glimpses of the man himself.

In a general sense the duties of a municipal engineer are known to most, but very few, we fancy, realise the very wide scope of his work as revealed in the operations described in these pages. To the lay mind the work of the municipal engineer is something quite technical and matter-of-fact, but the reader will be surprised to learn how much romance and humour are associated with it. Mr. Boulnois' light touch brings this out very clearly, and the style of his description adds interest to many of the works the engineer, in the course of his " daily round and common task," is called upon to carry out.

This book should also be of practical assistance to young engineers since the details of many pieces of work of exceptional character therein described show great resource in overcoming difficulties.

In addition to his experience in La Vendée, Jamaica, and at the Metropolitan Board of Works, Mr. Boulnois has held the offices of Municipal Engineer and Surveyor of Exeter, Portsmouth and Liverpool, and after spending something like fourteen years as one of His Majesty's Inspectors of the Local Government Board has now retired into private practice after a long, distinguished and honourable career of some forty-one years of strenuous life devoted to municipal engineering.

The book is full of interest from cover to cover, from the charming dedication :

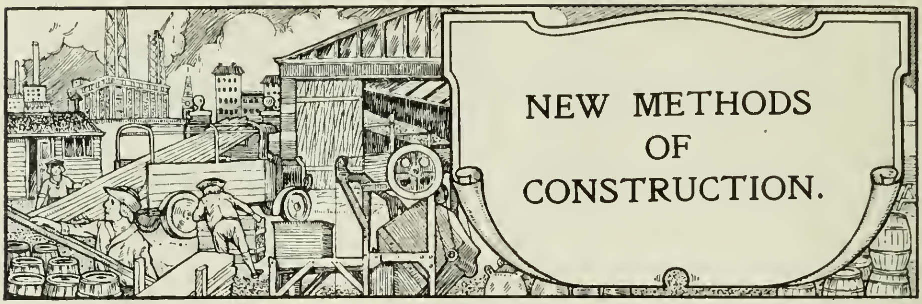
> " To her, to whom I owe all my happiness and any success I may have achieved in this life, to my dear wife."

to the final sentence : " Speculations as to the future are as fascinating as memories of the past. We laugh sometimes at the so-called barbarism and ignorance of the people who lived a hundred years ago, forgetting that a hundred years hence we shall, in turn, be laughed at for our present feeble efforts.

" We are children still, wayward and wistful,
With one hand we grasp the familiar things
We call our own, whilst with the other,
Resolute of will, we grope in the dark
For that the day will bring."

Lewis & Chandler's "Popular Handbook for Cement and Concrete Users."

We are asked to state that the price of this book, reviewed in our January number, is now 18*s*. The Publishers are Messrs. Henry Frowde, Hodder & Stoughton, 17, Warwick Square, E.C. 4.



A SIMPLE CONTRIVANCE FOR HOLDING DOWN RAILS TO CONCRETE FOUNDATIONS.

Whilst on a recent visit to probably the largest public works undertaking being carried out in this country our interest was roused in a detail of construction which may be novel to many interested in railway or tramway construction.

The detail in question was the simple and effective method employed on an extensive scale in the attachment of flat-bottomed rails to reinforced concrete slab foundations. We were informed that the system was adopted only after much thought and repeated experiments with existing types of attachments. It was found that these latter whilst leaving much to be desired from a practical and economical point of view even when used with plain concrete foundations were far more unsuitable when the problem was further complicated by the necessity due to bad foundations of reinforcing the concrete with double-layer interlocked reinforcement.

As we consider that the solution may be of interest to our readers, we herewith give a brief description illustrated by a photograph of work in progress and *Figs.* 1 to 5, in which latter—

Fig. 3 is a section on line 11 of *Fig.* 4 and shows the tramway rail *f* in elevation.

Fig. 4 is a cross section through the rail *f* on line 22 of *Fig.* 3.

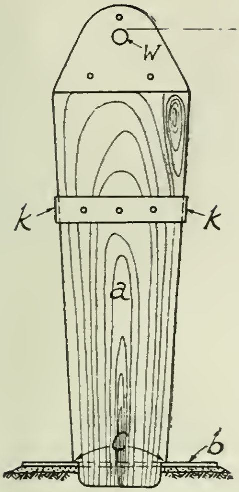
Fig. 5 is a cross section through the slot in the concrete raft *e* on line 33 of *Fig.* 4.

The procedure is as follows :—

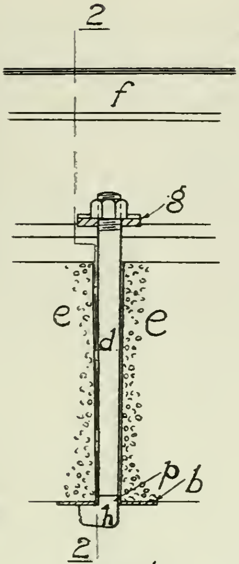
After the formation has been levelled off and the interlocked double-layer reinforcement laid in position the ganger attaches to the top layer of steelwork the marking out lines giving approximately the positions of the rails at desired spacings. On these lines he fixes vertically on the formation and transversely to the rails the tapered templates *a* (in *Fig.* 1) each fitted at the rebated lower end *c* with a loose thin slotted base plate *b* of thin stamped out metal shown in plan in *Fig.* 2.

Through a hole in the top of each template is passed a rod or bar connecting three or more templates together. The top of the horizontal bar is levelled off to rail level by packing up under the base plate *b* with sand. After all the templates are thus set up the concrete is put in position up to the lower edge of the iron band *k* on the template, the top edge of the band being identical in level with the underside of the rail *f* in *Figs.* 3 and 4. After the concrete is partly set the templates are slightly eased and subsequently removed completely when the concrete has set hard. This results in slotted holes in the concrete surrounded at the bottom of the raft by the flat slotted base plates *b*.

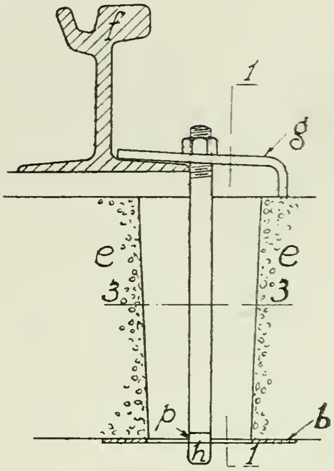
The rails are now brought on the site and laid in position on the concrete at the required level, being packed up on small premoulded concrete wedges or other suitable packing. Into the tapered holes in the concrete are dropped "L" headed bolts *d* having close up against the head a short length of square neck *p*. The bolt head is pushed down into the cavity, left below the base plate by the removal of the projecting lower end of the template, until the square neck is below the base plate. The bolt is then turned 90°, and pulled up until the square neck fits again in the slot of the base plate and so prevents the bolt from being turned round when the nut is being tightened. For convenience in fixing, the bolt is supplied by the makers with a notch cut in the top of the screwed end, which notch indicates the position of the "L" shaped head of the bolt.



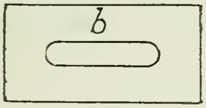
— Fig. 1 —



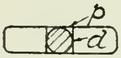
— Fig. 3. —



— Fig. 4. —



— Fig. 2. —



— Fig. 5. —

The bolt can be used to secure the rail either by passing through a hole drilled in the base of the rail or as shown in *Figs*. 3 and 4 by means of a bent clip *g*.

After the bolt nuts have been screwed down and the slotted holes filled with sand to within half an inch of the concrete surface the concreting is resumed and great care is taken thoroughly to pack and grout the concrete under the rail and so prevent any subsequent disastrous " pumping " action so common with rails badly bedded and fastened down.

It will be evident that the comparative cost of this procedure is negligible and consists in a small capital outlay in hard wood templates together with a few pence per hole for the cost of the thin stamped out bed plates *b*.

The necessity for anchorage consisting of inverted short lengths of rail buried in the concrete and for the packing up of the rails in their exact position over the trench before concreting is eliminated, and skilled supervision also in setting out, is reduced to a minimum. This latter is obvious as no careful setting out is required in fixing the templates as the resultant 5 in. or 6 in. length of the slot in the concrete gives ample margin for any slight error on the part of the ganger. Also the adjustment to rail level of the rod passing through the holes in the top of each template automatically ensures :—

(*a*) correctness in the level of the surface of concrete *c*.

(*b*) ample uniformly regulated space for packing and grouting under the rail.

(*c*) uniform length of bolts.

In the case of renewals due to settlement, wear, or otherwise, it is a simple matter to take out and renew the bolts and to securely attach the rail again without having to place imperfect reliance on green immature concrete or grout in lewis holes or such-like.

The above system, which has been found applicable to other uses in securing structural members other than rails to either plain mass concrete or to concrete rafts is the invention of Mr. J. H. Walker, A.M.I.C.E., who contributed the interesting article on overhead strut cableway cranes illustrated in our issue of February 1920, under the heading of "Notes on a suggested Solution of the Housing Problem." We understand that Messrs. The Walker-Weston Co., of 7, Wormwood Street, E.C.2, have undertaken the commercial development of the system in all its applications in conjunction and otherwise with their now well-known system of pyramidal interlocked double-layer reinforcement.

QUESTIONS AND ANSWERS RELATING TO CONCRETE.

***In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.*—Ed.**

Question.—E. C. L. writes :—Is reinforcement necessary or advantageous in a concrete road ?

Answer.—This really resolves itself into two questions which are closely related, and it is difficult to answer one without referring to the other.

1. *Is reinforcement necessary ?* This is entirely a question of circumstances. In cases where the road bed is bad, reinforcement is absolutely necessary. If the bed is doubtful it is certainly advisable that the road should be reinforced.

Then again, where heavy traffic has to be provided for, we should say that reinforcement is a necessity. In America many of the lightly trafficked roads are of plain concrete.

2. *Is reinforcement advantageous ?* Undoubtedly, yes. In the first place, the concrete in a road which is not reinforced must be thicker than that in a road where reinforcement is employed, if the same degree of strength is to be attained. And further, where there is any tendency to crack, the reinforcement spreads this tendency over a wide area with the result that the cracks, where they exist at all, are so minute as often to be invisible and therefore the road slab suffers no detriment.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—Ed.

Cost of Laying Block and Brick, and Comparative Strength.—Writing to our contemporary, *Concrete, U.S.A.*, Mr. H. G. Krum gives some interesting particulars of his experience regarding block and brick laying. He says :—

" In bidding on a three-storey factory building to be erected in the near future in St. Paul, we had occasion to prepare a table to show the owner and architect the cost of erecting block walls. The first two storeys of the building had to have 16 in. walls, in order to meet with the city requirements. We did not happen to have very many 16 in. tamp units on hand, so had to figure two 8 in. blocks for each course, using a course of 16 in. blocks every fifth course for a header.

" This table may be of interest in retelling the story that the cost of erecting blocks is very much less than laying up brick. It also shows that a well-made concrete unit will carry a much greater load than common brick. The cast units on hand showed a test of 2,000 lb. to the square inch ; the tamp units a test of 1,200 lb., and the brick (sand lime) 450 lb."

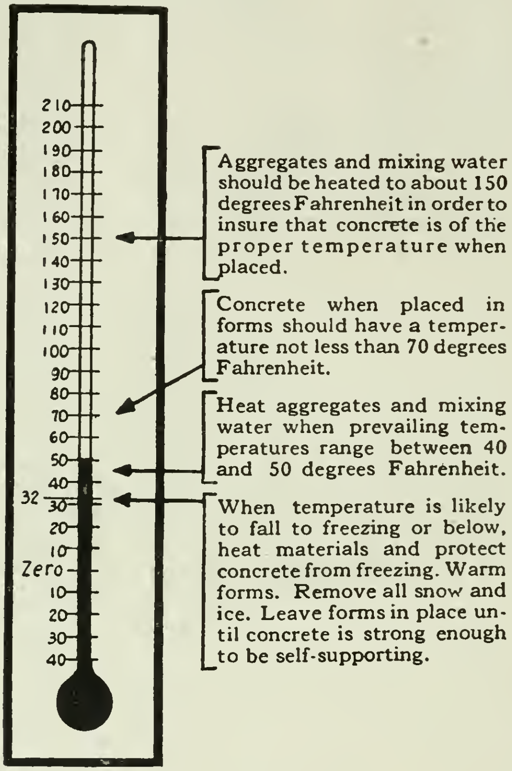
Comparative Cost per 100 Sq. Ft. of 16 In. Wall Material, Labour and Mortar Cost at Present Market Prices.

	Cast 1—12" and 1-4" alternately.	Tamp 2—8" with 16" block for Hdr.	Brick—Solid sand lime.
Material cost on job (no hoisting, etc.)	$55·13	$54·00	$53·34
Labour laying	15·28	15·72	35·55
Mortar cost	3·75	4·92	10·20
Approximate cost per 100 sq. ft. of 16 in wall	$74·16	$74·64	$99·09
Material required per 100 sq. ft. of wall	73-12" 73- 4"	182-8" 15-16"	2667
Ultimate crushing strength per lin. ft. of wall	208,000	111,600	86,400
Safe load (10 per cent.)	20,800	11,160	8,640
Blocks laid per day	125	200	1,200
Blocks per cu. ft. of mortar	24	32	156
Mortar per cu. ft.	—	—	$0·60
Mason per day	—	—	$10·00
Helper per day	—	—	$6·00

Effect of Paint on Reinforcement.—A series of tests, undertaken by the United States Bureau of Standards to determine the effect of preservative coatings on the bond resistance of reinforcing bars embedded in concrete, has resulted in the following conclusions being arrived at :—The maximum bond stress developed by painted bars was generally considerably less than the bond resistance of unpainted bars, but the reduction in maximum bond resistance due to galvanising and similar processes was less than that due to painting.

Concrete Cross Roads Signs.—The Illinois Division of Highways has announced that concrete mileage posts, surmounted by Illinois-shaped concrete markers, which together will stand 6 ft. high, are to be placed at all cross roads on three state highways.

Placing Concrete in Cold Weather.—In our December number we published an article on this subject, and in further reference to the information given there, the accompanying chart and instructions, which more or less embody the points emphasised in our December number, may be useful. We are indebted to the Portland Cement Association of Chicago for this diagram and the accompanying text.



Aggregates and mixing water should be heated to about 150 degrees Fahrenheit in order to insure that concrete is of the proper temperature when placed.

Concrete when placed in forms should have a temperature not less than 70 degrees Fahrenheit.

Heat aggregates and mixing water when prevailing temperatures range between 40 and 50 degrees Fahrenheit.

When temperature is likely to fall to freezing or below, heat materials and protect concrete from freezing. Warm forms. Remove all snow and ice. Leave forms in place until concrete is strong enough to be self-supporting.

Heat aggregates and mixing water so that concrete when placed will have a temperature not lower than 70 degrees. Place concrete in the forms immediately after mixing so that none of the heat will be lost.

Protect concrete as soon as placed in order to retain the heat. Canvas covering, sheathing or a layer of clean straw will furnish sufficient protection for some work. Where work can be enclosed, open coke stoves or salamanders may be used. In severe weather such protection should be continued for at least five days.

Be sure concrete is strong enough to bear load before forms are removed. Examine by pouring hot water on concrete or by heating in some other way to be sure concrete has hardened, not merely frozen.

CONCRETE AND HOUSING SCHEME.

Ashburton.—The Ashburton Urban District Council has instructed its Architect to invite alternative tenders for the erection of houses in brick and concrete.

Ayr.—The Ayr District Committee of the Ayrshire County Council has instructed its Road Surveyor to obtain tenders for the erection of fourteen houses at the Old Mill, New Cumnock, in brick and in concrete.

Batley.—The General Works Committee of the Batley Town Council has passed plans for ten concrete houses, to be erected in Grange Road, Staincliffe, for Councillor G. R. C. Fox of Staincliffe Hall.

Bath.—An inspector of the Ministry of Health has informed the Bath Town Council that H.M. Office of Works is prepared to erect fifty concrete houses in the city, and the Council's Architect has been instructed to obtain further information on the subject.

Hucknall.—A deputation from the Hucknall Urban District Council has visited the Birmingham concrete housing scheme, and has reported in favour of the adoption of concrete construction for the Hucknall housing scheme.

Kirkintilloch.—Owing to the difficulty of obtaining bricks, the Kirkintilloch Burgh Council has empowered the Housing Committee to acquire plant for the manufacture of concrete blocks, if necessary.

Leeds.—The interest in concrete houses taken by local authorities may be gauged by the fact that no fewer than 500 of them have sent representatives to Leeds to inspect the concrete housing scheme at Meanwood. These houses are being erected by Messrs. William Airey & Son, Ltd., on the slab system.

Manchester.—Two bungalows are to be built, as an experiment, on the Mount Road Estate, Manchester, by the Manchester City Council, on a system of concrete block construction evolved by Alderman James Johnston. In this system pre-cast concrete units, twenty-eight in number, are used, and placed in position by crane power; the roofs are formed of concrete slabs. It is claimed that the bungalows, which contain a large living-room, three bedrooms, kitchen, scullery, and usual offices, can be built in quantities of from 50 to 100 at £500 or £600 each, as compared with houses with similar accommodation being built by the Manchester Corporation at from £1,000 each.

Merthyr.—The Merthyr Housing Committee has sent to the Housing Commissioner a tender of Messrs. Dorman, Long & Co., for the erection of steel and concrete "Dorlonco" houses at the following prices: non-parlour houses, £894 each; parlour type houses, £1,017.

Newcastle-on-Tyne.—The Newcastle-on-Tyne Corporation has signed contracts for the erection of 265 houses at Walker, 50 of which are to be of concrete.

Ormskirk.—As the result of experiments with concrete blocks, the Ormskirk Urban District Council has decided to apply to the Ministry of Health for a loan of £22,000 for the purchase of plant and materials for the manufacture of concrete blocks for use on its housing scheme.

Plymouth.—The Housing Committee of the Plymouth Town Council has recommended the erection of 250 houses on the "Duo Slab" concrete system, and also the erection of a sample pair of concrete-slab houses.

Rawmarsh.—The Rawmarsh Town Council proposes to enter into a contract with Messrs. Hopkinson & Co. for the erection of a further seventy houses on the High Road site (making 100 in all) on the "Dorman Long" system.

Rugeley.—The Rugeley Urban District Council has decided to erect concrete houses by direct labour, and plans have been prepared by the Surveyor and submitted to the Housing Commissioner for the area.

Salisbury.—An interesting experiment is being tried by the Salisbury Town Council, in conjunction with the local Master Builders' Association, in the direction of employing unskilled ex-Service men on its housing scheme. Twenty houses have already been commenced, and some fifty unemployed ex-Service men engaged. The houses are being built of concrete blocks, manufactured on the site, and careful costs are to be kept. The scheme has the approval of the Ministry of Health.

Whiston.—The Whiston Rural District Council has passed plans for four concrete houses at Warrington Road, Bold, two concrete houses at Mill Lane, Rainhill, and eight concrete houses at Holt Lane, Whiston, for the Lancashire County Council.

The Ministry of Health.—We desire to call attention to the General Housing Memorandum (No. 40) recently issued which deals with the problem of Smoke Abatement in connection with the design and equipment of dwellings. Copies of this memorandum can be obtained from the Ministry of Health on application.

PROSPECTIVE NEW CONCRETE WORK.

Blairgowrie.—The Blairgowrie District Committee of the Perth County Council is considering the question of repairing four large breaks in the embankments of the River Ericht, at a cost of £3,500.

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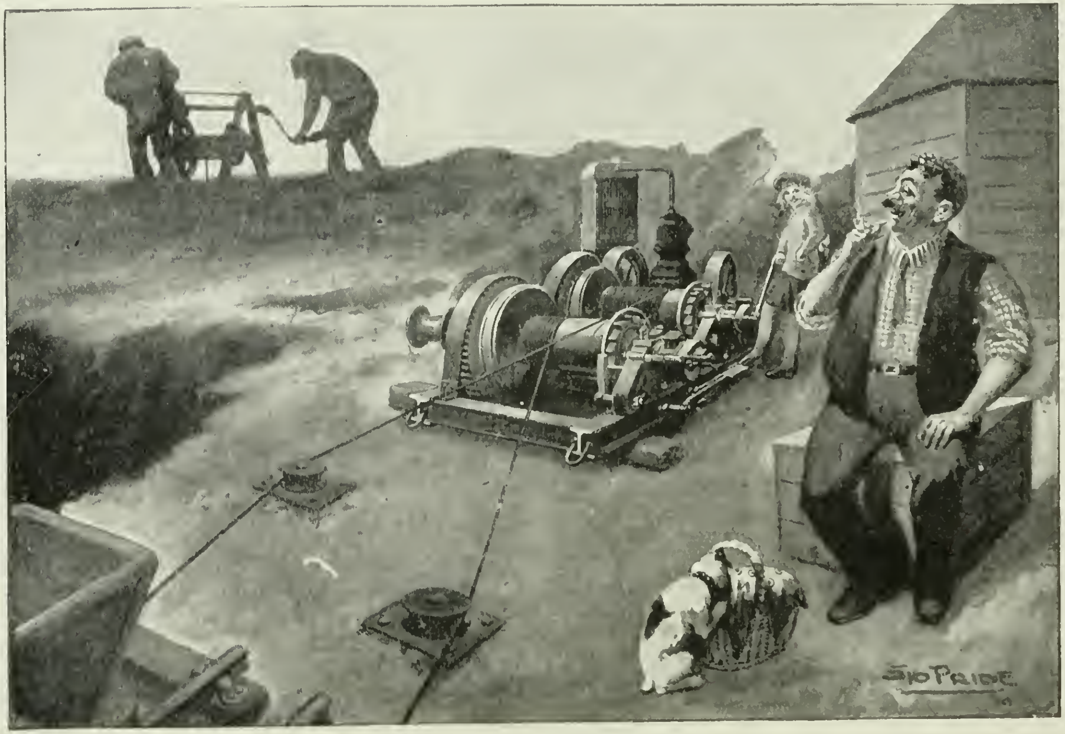

The British Steel Piling Co.,
Dock House, Billiter Street, London, E.C.3.

Bradford.—The Streets, Drainage and Works Committee of the Bradford Corporation has recommended the Corporation to purchase a concrete mixer, and stonebreaker, and other machinery for use in road works.

Bridge of Allan.—The Bridge of Allan Town Council has decided to apply for powers to construct a new waterworks, at a cost of £25,270.

Brierley Hill.—The Brierley Hill Urban District Council has agreed to the construction of a new canal bridge, at a cost of £2,500.

Carnarvonshire.—The Carnarvonshire County Council has agreed to the construction of a reinforced concrete bridge at Croesar, at a cost of £5,700.

Colchester.—The Harbour and Navigation Committee has recommended the Colchester Town Council to submit a scheme of harbour improvement to the Ministry of Transport.

Crewe.—The Crewe Town Council has instructed the Borough Engineer to prepare designs for alternative types of bridges at Alton Street.

Dartmouth.—The Dartmouth Town Council is considering a report by Messrs. J. & W. Purves, Consulting Engineers, of Exeter, for the construction of a new reservoir, at a cost of £34,000.

Grimsby.—The Town Council has authorised the construction of six pairs of elevated concrete silos, at a cost of £3,200, in connection with a scheme for unloading railway trucks in the yard of the Highways Department.

Lambeth.—The Lambeth Borough Council has decided to offer no objection to the construction of a steel and concrete extension of the stand at Kennington Oval by the Surrey Cricket Club.

Millom.—The Millom Urban District Council has decided to construct a new reservoir, with a capacity of 20,000,000 gallons, at a cost of £50,000.

Ruislip-Northwood.—The Ruislip-Northwood Urban District Council has decided to apply to the Ministry of Health for sanction to borrow £430 for the construction of a concrete retaining wall at the Eastcote Pinner Road.

Sidmouth.—The Sidmouth Urban District Council has adopted a report of its engineer, which provides for a scheme of sea defence works at a cost of £27,000.

Stirlingshire.—The Stirlingshire County Council is promoting a Provisional Order for authority to construct new reservoirs and embankments, at a cost of £240,045.

Yarmouth.—The Yarmouth Port Committee has reported that an immediate expenditure of £214,120 is essential for the proper repair and upkeep of the harbour.

Yeovil.—The Yeovil Town Council has applied to the Ministry of Health for sanction to borrow £800 for the erection of a concrete shed, and to instal therein a travelling pulley block.

NEW METHODS AND MATERIALS.

The following is a further list of materials and new methods of construction approved by the Standardisation and Construction Committee :—

A. J. Dunn, 5a, Temple Row, Birmingham.—The "Con-cog" system of concrete construction consists primarily of pre-cast interlocking units, including stancheons, beams, joists, purlins, roof, floor and walling slabs, chimney-flues, door, window and other dressings.

Reginald Brown, Osterley, Longford Avenue, Southall.—The "Elzed" System.—The system is one of pre-cast units designed to make even the setting out of a building a comparatively simple operation, whilst the construction is such as to give a perfect bond in walls.

Features of the system are the use of sill-plates and Z-shaped wall-blocks forming a series of hollow rectangles which can be left hollow or filled with poured concrete.

J. E. Wilkes, A.M.I.C.E., City Engineer, Oxford.—The method of building is a cavity wall with plain concrete slabs, headers being provided alternately with stretchers in each course.

W. C. Murchison, c/o Tasmanian Agent General, Australia House, Strand, W.C.—A system of shuttering which consists of the use of angle steel uprights, which are firmly held together by angle irons at top, fastened in such a way as to be readily adjustable to any class of building, with steel sheets of various lengths which are moved upward two feet per day, thus forming a monolothic wall.

J. Weston, 2, Harewood Place, Hanover Square, W.7.—The "Weston" System.—The blocks are made of terra-cotta or clinker. In the former case the space between the wings is filled with clinker concrete. The blocks are placed in position with wings adjoining and one above the other, no bedding in mortar being necessary.

Centreing is erected on the outside face, and concrete is poured between this and the blocks. A small vertical rod is placed in each rib and also every 18 inches horizontally. The finished wall is a ribbed structure of reinforced concrete.

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IS efficient, portable and handy to operate.

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TENDERS ACCEPTED.

Housing.

Cheltenham.—The Cheltenham Town Council has accepted the tender of Messrs. W. T. Nicholls, Ltd., for the erection of 20 steel and concrete houses on the "Dorman Long" system, at a cost of £998 each (subject to modification).

Houghton-le-Spring.—The Houghton-le-Spring Rural District Council has accepted the tender of Messrs. W. Airey & Sons, Ltd., of Leeds, for the erection of 213 Type "A" concrete houses at £870 per house, and 137 Type "B" concrete houses at £990 per house.

Leyland.—The Leyland Urban District Council has accepted the tender of the Leyland and District Building Employers' Association for five concrete block houses, at £905 19*s.* each.

Llanelly.—The Llanelly Town Council has accepted the tender of Messrs. W. T. Nicholls, Ltd., for the erection of 150 steel and concrete houses, on the "Dorman Long" system, at a cost of £148,057.

Newcastle-on-Tyne.—The Housing Committee of the Newcastle-upon-Tyne Corporation has accepted the following tenders for the erection of concrete houses, in groups of twenty, on the Walker Estate :—S. Miller, North Street, 79 houses at £72,859 ; G. G. Carr, Worswick Street, 81 houses at £73,991 ; A. Anderson, Biddlestone Road, 18 houses at £16,558 ; Braithwaite & Co., Black Whitefield Terrace, 19 houses at £17,449 ; J. S. Hetherington, Westgate Road, 18 houses at £16,558. (All of Newcastle-upon-Tyne.)

General.

Bromley (Kent).—The Works and Stores Committee of the Metropolitan Water Board has recommended the acceptance of the tender of Messrs. R. Robinson & Co. for the construction of a covered service reservoir at Bromley, Kent, for the sum of £53,357 13*s.* 7*d.*

Esquimault (Canada).—The contract for the construction of a dry dock at the Esquimault Navy Yard has been awarded to Messrs. T. P. Lyall & Sons Construction Co., of Montreal, at £860,000.

Mansfield.—The Town Council has accepted the tender of Messrs. Lane Bros., of Mansfield, for the construction of about 1,800 yards of concrete tube sewer, etc., for the sum of £28,439 18*s.* 6*d.*

Southend-on-Sea.—The Town Council has accepted the tender of Messrs. Millar's Trading Co. for the supply of concrete mixing plant, for the sum of £300.

TENDERS INVITED.

Willesden.—February 14. For the erection of seventy-six concrete houses on the "Fidler" system, for the Willesden Urban District Council. Plans, etc., from the Borough Engineer, Municipal Offices, Dyne Road, Kilburn, N.W.

Ely.—February 17. For erection of 8 houses at Wilburton, for Ely Rural District Council. Plans, etc., from Messrs. Spalding, Myers & Theakston, Architects, 12, New Court, Lincoln's Inn, W.C.2.

East Grinstead.—February 21. For erection of forty houses, by alternative methods of construction, for the East Grinstead Rural District Council. Plans, etc., from Mr. Charles Turton, Architect, 36, High Street, East Grinstead.

Hollingworth.—February 22. For erection of twelve houses for the Urban District Council. Plans, etc., from Mr. H. Wilson, Clerk to the Council, Norfolk Square, Glossop. Deposit £3 3*s.*

Maldon.—February 22. For erection of eighty-eight houses for the Maldon Urban District Council. Plans, etc., from Mr. W. Almond, Surveyor, 6, Market Hill, Maldon.

South Africa.—Tenders are invited by the Government of South Africa for the construction of one grain elevator (30,000 tons capacity), at Cape Town ; one elevator (42,000 tons capacity), at Durban ; and thirty-four smaller grain elevators in various districts, in connection with the South African Railways and Harbours. Full particulars from the High Commissioner for the Union of South Africa, 32, Victoria Street, London, S.W.1. Sending-in day, May 2.

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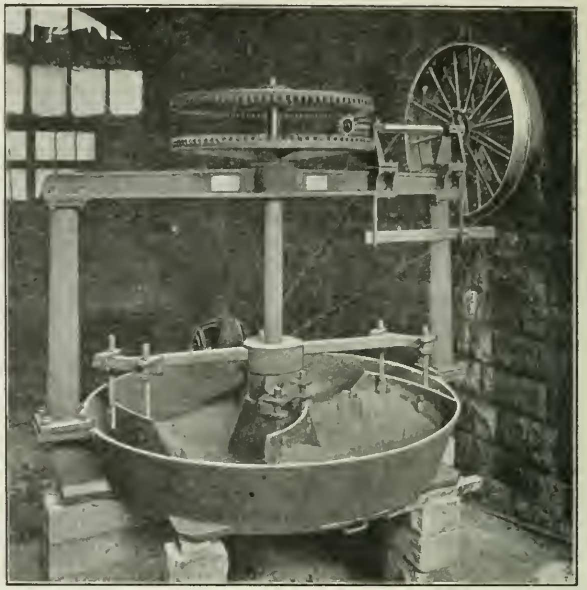

A New Concrete Mixer.—A new concrete mixer has recently been put on the market by Messrs. R. H. Kirk & Co., of Collingwood House, St. Peters, Newcastle-on-Tyne. The mixer, of which we give an illustration, is a double-motion mixer and can be operated either by hand or power, and it is said to adapt itself equally well to wet, semi-wet or dry ingredients. Among the advantages claimed are the following :—It is a batch mixer, which ensures that the mixture is composed of the exact required proportions ; certainty of action ; the ploughs revolving in opposite directions give a balanced effect, thus reducing working depreciation to a minimum ; there is a wide range of adjustment and simplicity in design. Further, the ingredients are turned over four times with every revolution of the ploughs, and very little power is required. The discharge of the mixed materials is effected through a sliding door in the bottom of the mixing pan.

TRADE NOTES.

Hayes System of Concrete Cavity Walling.—In our December number we gave an illustrated description of this system on page 839. Messrs. Hayes ask us to add that the shuttering in connection with their system is very simple to fix, and, spread over a number of houses, the cost is very small. It has a long life, and the number of times it can be used is unlimited. The cost of putting the concrete into position is also considerably reduced, and walls can be erected at a reduced cost as against brick or other walls erected by skilled labour.

For further particulars readers should apply to Messrs. W. P. & P. G. Hayes, Lyme Street, Warrington.

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CONTRACTOR'S AGENT with considerable experience in Reinforced Concrete Construction and Public Works generally, seeks re-engagement. Age, 40. Good executive ability. First class references. Box 189, c/o Concrete and Constructional Engineering, 4, Catherine Street, London, W.C.2.

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APPOINTMENTS VACANT.

REQUIRED for India Factory Manager for Concrete Product Works. Must have good organizing and technical (mechanical) qualifications ; also preferably knowledge reinforced concrete works and experience of Indian labour. Write stating age, experience, etc., to Box "S.E.," Davies & Co., 95, Bishopsgate, E.C.2.

ASSISTANT Engineer Specialist in reinforced concrete design and practice required at once for Bombay. Good salary. Apply H. Wolff, 18, Park Road, Hampton Hill, London, S.W.

MISCELLANEOUS.

THE PUBLIC WORKS DEPARTMENT, KENYA COLONY, are desirous of receiving trade CATALOGUES dealing with the BUILDING and ENGINEERING trades. Any statements of approximate prices with trade and other discounts will be of great value and will be treated as confidential. Catalogues should be posted to the Honourable Director of Public Works, P.O. Box 62, Nairobi, Kenya Colony.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 3. LONDON, MARCH, 1921.

EDITORIAL NOTES.

THE BUILDING TRADES' EXHIBITION.

THE second post-war International Building Trades' Exhibition is to be held from April 12 to 26, and the venue, as last year, is to be Olympia. Space has been readily taken up, and the show promises to be as successful as last year's. From the point of view of concrete, last year's exhibition was, no doubt, the most interesting ever seen in this country, as it was held after a lapse of six years and embodied not only the progress made during the period of the war but also demonstrated the extent to which the material was being used to overcome the housing shortage. During the past year large numbers of concrete houses have been built or commenced on the systems on view at last year's Exhibition, and it is certain that many new ideas will be open to inspection at the forthcoming show. Although, however, housing may be expected to dominate the constructional side of the Exhibition, it is to be hoped other adaptations of concrete will be on view, such as farm buildings (poultry houses, cattle stalls, pigsties, etc.), fencing, sign-posts, telegraph posts, railway sleepers, tanks, drinking troughs, and many other purposes for which concrete is being used with advantage and economy.

We hope, also, that the artistic side of concrete will not be overlooked, and that those interested and the general public will be afforded an opportunity of seeing sample slabs with exposed aggregate, showing the delightful effects that can be obtained by this treatment. Such a demonstration would go a long way to dispel the view, which is still often heard, that concrete can only be a dull, uninteresting, monotonous-coloured material.

A list of some of the firms who have taken up space on the ground floor for the forthcoming Exhibition will be found in another part of this issue.

CONCRETE AND ARCHITECTURE.

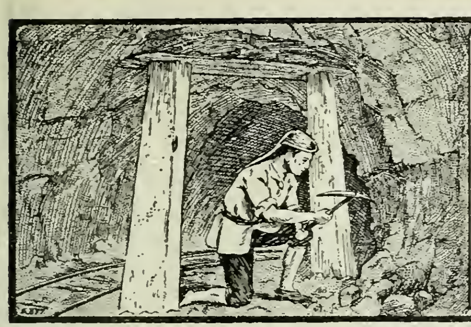
AT a meeting of the Royal Institute of British Architects last month Mr. W. E. Willink, F.R.I.B.A. (of Messrs. Willink & Thicknesse, the architects for the building), gave an account of the Cunard Building, Liverpool, which was illustrated and described in our issue for November, 1917. This building, which is one of the finest erected in this country in recent years, is of reinforced concrete with stone facing, and speaking of the concrete work Mr. Willink said : " I need hardly enlarge on the merits of reinforced concrete. One of its chief drawbacks is one which affects not us, but maybe our grandchildren. When it is decided to destroy the Cunard Building to make way for a thirty-storey building on its site, I feel sorry for the contractor who has to do it. I suppose, however, one could hardly expect a building proprietor to regard as an important quality in his building that facility of demolition which might appeal to his great-grandson." When considering the merits of a building there is so often a tendency to do so on its external appearance only that it is a pleasure to hear such an eminent architect as Mr. Willink speak in euoglistic terms of the reinforced concrete work which, after all, in many cases makes the design possible.

SLAB CONCRETE ROADS.

ALTHOUGH concrete roads are now past the experimental stage, and are proving their superiority over other forms of road construction by the test of use under practical conditions, the concrete roads laid in this country up to the present have, so far as we are aware, all been built *in situ*, with some form of reinforcement. An experimental section of roads laid with pre-cast concrete slabs which has been built at Taunton will, therefore, be watched with considerable interest. The costly operation of opening up and relaying roads when it is necessary to repair existing underground gas, water or electricity mains, or sewers, or to lay new ones, is common to all types of roads, and it is partly with the object of minimizing this item of expenditure that the experiment is being made. When such excavations are required under a road constructed with slabs, the necessity for breaking up the surface and re-paving with new concrete is eliminated ; it is only necessary to lift the slabs and replace them when the repairs have been carried out. A further advantage is that when the slabs become worn they can be replaced with new slabs from stock in a very short time, and traffic can be resumed without the usual delay of waiting for the new concrete to set. In the construction of new roads, also, as the surface is laid with matured pre-cast slabs, the usual period of three weeks or so which has to be allowed whilst roads laid *in situ* are setting is dispensed with, and thus one of the objections often levelled at concrete roads by local authorities is removed.

The experiment in question is being carried out at Taunton, and was described by Mr. J. F. Shellard, A.M.Inst.C.E., the Borough Engineer, at a meeting of the Institution of Municipal and County Engineers last month. The section on which the experiment is being carried out is some 20 ft. in length in a busy street. The slabs are 3 ft. 6 in. long by 2 ft. wide by 5 in. thick, laid to break joint. For the purposes of the experiment the slabs are made of various aggregates, some being reinforced and some not. No special foundations have been prepared, but the slabs are embedded on mortar composed of sand and cement in the proportion of six to one. Expansion joints are provided by leaving a space of $\frac{1}{8}$ in. between the slabs and filling it in with a tar compound. In a table of comparative costs, the first cost of laying roads by this system is given as slightly higher than for reinforced concrete roads laid *in situ*, viz., £1 1*s*. 9*d*. as against 19*s*. 8*d*. per yard, but over a period of years, as is shown by a comparative table, it is anticipated that the lower cost of repairs will more than counterbalance this and show a saving.

The experiment has now been in progress for three months, and Mr. Shellard states that the section is wearing well. If satisfactory results are obtained after a fair length of time, the Council is to be recommended to lay further sections of roadway on the same principle. He expressed the opinion that he had no fear as regards the strength of the slabs and their ability to bear heavy traffic ; the only doubt was whether they would become loose through rocking as traffic passed over them. Mr. Shellard's full paper will appear in a subsequent issue.

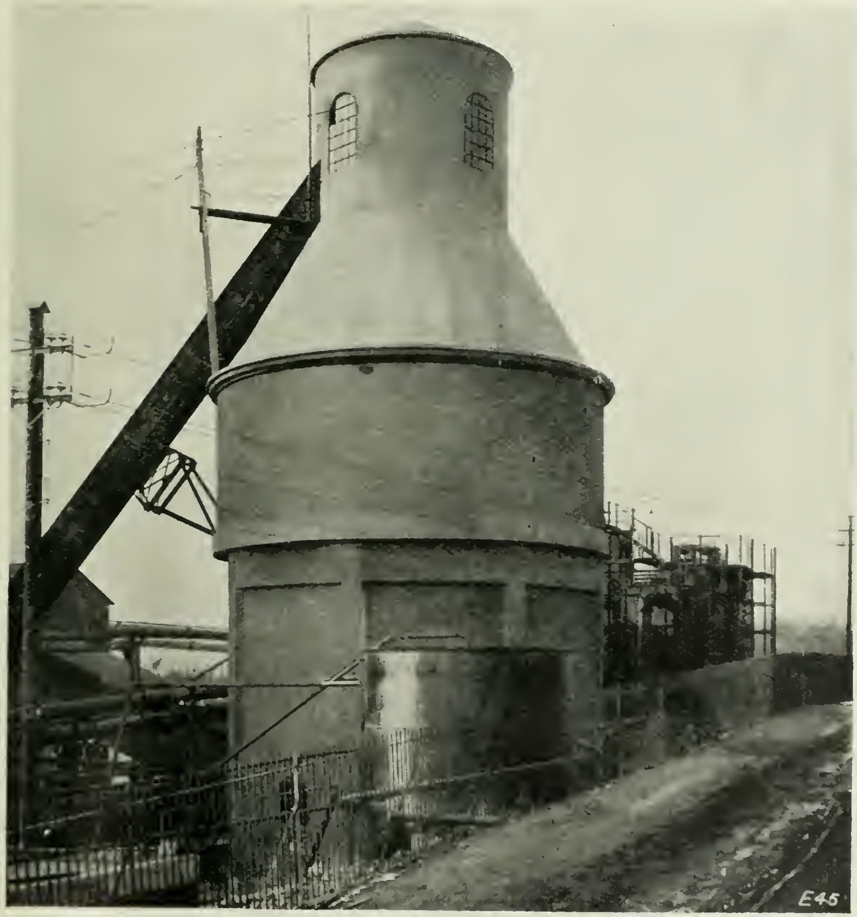


CIRCULAR COAL STORAGE BUNKER AT CHAPELTOWN, NEAR SHEFFIELD,

FOR MESSRS. NEWTON CHAMBERS & CO., LTD.

By R. STUBBS, A.M.C.I.

THE circular form of bunker, constructed in steel, has been in use for some years by its designers, The Coke Oven Construction Co., Ltd., who have built fifteen bunkers of this form, of capacities varying from 600 to 1200 tons.

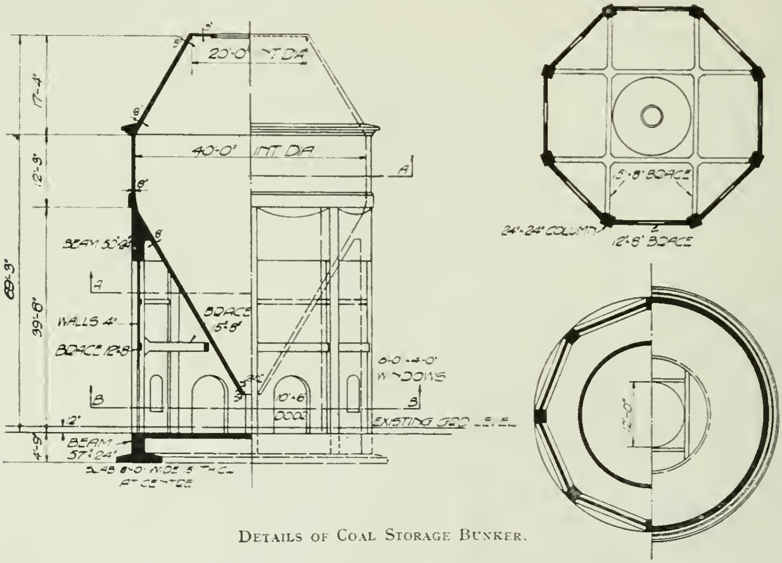


VIEW OF FINISHED BUNKER.

During the War they desired to erect another circular bunker in connection with work for Messrs. Newton Chambers & Co., Ltd., for which they were the mechanical engineers, but owing to the embargo on steel another material had to be found, and they entrusted the design of a circular bunker in reinforced concrete to the Trussed Concrete Steel Co., Ltd.

The most striking feature of this bunker to an experienced engineer is the extremely small amount of material used in its construction. Although the capacity of the bunker is 750 tons, the amount of concrete in the whole structure, including the bases and walls, is under 400 yards cube. This economy is apparent also in the amount of reinforcement, of which only about 21 tons was used.

This saving of material was effected by eliminating bending stress wherever possible, and it is for this reason that the bunker was made circular. The hopper mouth, therefore, originally was conical, but at the request of the contractors, Messrs. Stuart's Granolithic Co., Ltd., was eventually altered to a twenty-four sided pyramid. Quite obviously the labour in forming the centering of this pyramid was considerable, but as this centering was used again for the top of the bunker, which, it will be noticed, is in the form of the frustrum of a twenty-four sided pyramid, the cost per yard super was relatively low. Surmounting the hopper itself is a motor house in which the machinery for operating the inclined elevator is housed ; the material is conveyed to the bunker from the washery by this elevator, which is clearly shown in the accompanying illustration. At one side of the bunker the roadway runs on a level approximately 12 ft. above the floor level of the lower house ; this house has been formed by filling in between the concrete columns with a reinforced concrete slab.



Details of Coal Storage Bunker.

The details of the reinforcement were designed by the Trussed Concrete Steel Co., Ltd. It is interesting to note, however, that the circular rings to the hopper mouth consisted of $\frac{5}{8}$ in. diameter round rods, suitably lapped at their junctions, the laps in adjacent rings being, of course, staggered, while the hanging steel, i.e., the steel which was placed for the purpose of hanging the hopper mouth up to the main beam, consisted of $\frac{3}{4}$ in. Kahn Rib bars. In several other instances, too, the combination of round rods and Rib bars has been employed, each in the position most suited to its particular merits.

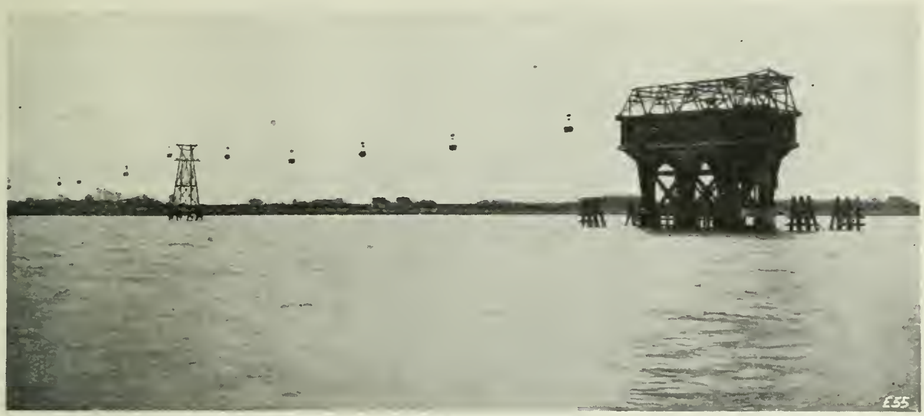


Fig. 1. The Completed Hopper.

A 700-TON GRAVEL HOPPER.

By V. ELMONT, B.Sc.

THE hopper described in the following lines presents some special features in so far as it is built 350 yards from the shore at a place where the depth of the water is 15 ft., and is designed as a combination of reinforced concrete and timber which has proved to be eminently efficient and economical.

As illustrated in *Fig.* 1, the gravel is transported from land to the hopper by means of buckets travelling on a cableway supported by a special framework

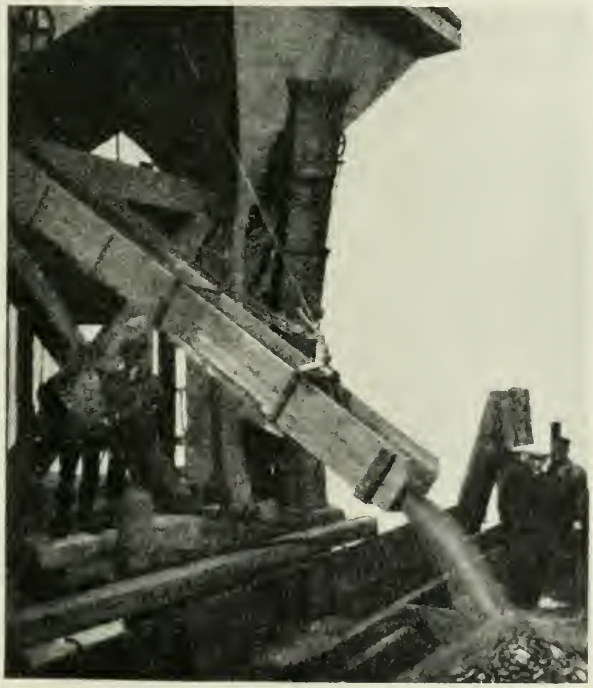


Fig. 2. Showing Discharge of Gravel through Spout.

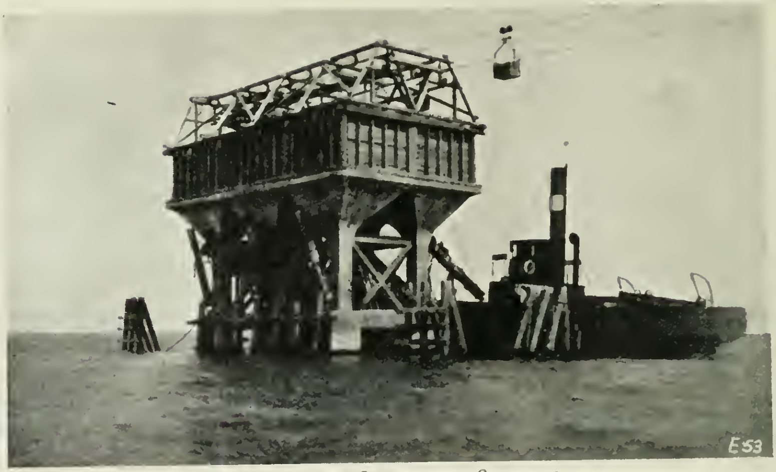


Fig. 3. Showing Supports for Cableway.

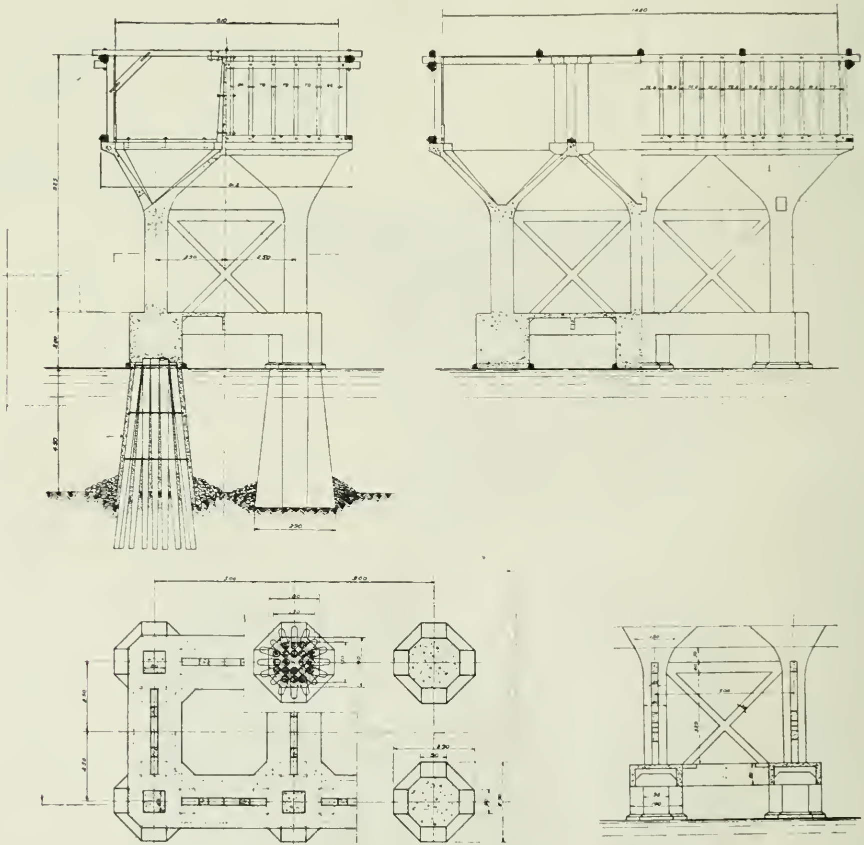


Fig. 4. Details of Construction.

on top of the hopper and towers erected in the sea between the crushing and screening plant on the shore and the hopper.

The storage capacity was made 700 tons, that is somewhat larger than twice the dead weight of the small steamers into which the gravel is discharged.

In *Fig.* 3 will be seen one of these vessels lying alongside, ready to receive its load after the movable spouts have been swung into position. The process of filling the holds takes about 15 to 20 minutes. *Fig.* 2 depicts one of the spouts through which gravel is just being poured into the boat.

The foundation for the hopper consists of six heavy concrete piers cast around clusters of wooden piles (see *Fig.* 4). About 6 ft. 6 in. above the water line the piers are interbraced by a reinforced concrete floor system. Each of them carries a 31 in. × 31 in. concrete column, stiffened by diagonal bracing. The column capitals are hollow and form the hoppered bottom of the superstructure whose walls are built entirely in wood. The supports for the cableway over the hopper are also formed by a timber construction as will be realised from *Figs.* 1 and 3.

The columns are spaced 16 ft. 5 in. centre to centre and their height measured to the top of the capital is 26 ft. 7 in.; above this level are placed the 10 ft. 4 in. high wooden hopper walls.

The design and construction of this novel engineering structure, which was built near Copenhagen, are the work of the Northern Engineering Company "Cyclone," Ltd., Copenhagen, whose managing director, Mr. K. Hojgaard, is the originator of the plans.

MEMORANDA.

Reconstructing a Railway Viaduct.—Some interesting reconstruction work on a three-span continuous beam railway viaduct on the Sul Espirito Santo (Brazil) line of the Leopoldina Railway Company was given by Mr. F. W. Adolph Handman in a Paper before the Institute of Civil Engineers. The old girder was 197 ft. long, of the steel-lattice deck type, supported by masonry abutments and two trestles spaced 65 ft. 8 in. between centres. The gradient on the viaduct was 3 per cent. Calculations revealed that the girder and trestles were inadequate to carry a contemplated increase of live load, and it was decided to reconstruct the trestles and to use three whole-plate deck-girders of 65 ft. 8 in. span each, the weight of each girder being 38 tons. The steel trestles, being inadequate as such, were encased in concrete. Particulars of the concrete used and the special methods of depositing were given by the author, who also described the method of placing the girders in detail, the advantages claimed being that—(1) No falsework was employed. (2) The only plant required were four 50-ton ship's hydraulic jacks, two ordinary 20-ton wagon bogies and an oxy-acetylene apparatus for cutting steel. (3) The substitution was carried out without interruption to the ordinary passenger traffic, the interval between trains being 24 hours.

Each complete span was riveted up at a convenient siding about two miles away, and run into position over the old span on two 20-ton bogie trucks. By means of wooden cribs and hydraulic jacks, the girder was lowered to rail-level. The end sway braces and laterals of the old girder were then cut away by means of the oxy-acetylene apparatus, and the new girder was supported by cribs directly on the abutments or piers. The continuous girder was cut completely through over the pier, the two sections being slid outwards on special guides, the new girder being then lowered into place and the track fixed. Each girder was placed in a similar manner, and in each case within the allotted time.

Concrete Brine Troughs.—In order to protect the steel railway bridges from the damage done to them by the brine from refrigerator cars, a narrow concrete trough, placed midway between the rails and designed to catch the fluid, is being installed on all steel bridges of a Michigan railroad. Concrete is unaffected by salt solutions. —*American Architect.*

CONCRETE COTTAGE BUILDING.

HOUSE AT PETERSHAM.

In our issue for February last year we gave an account of the steel-framed houses at Dormanstown, the town which is being built by Messrs. Dorman, Long & Co., for their employees. This method of construction, the steel frame covered with Hy-Rib expanded metal which is concreted to form the outer skin of the hollow wall, while the inner leaf is formed with breeze blocks, has proved so successful that it is being used in all parts of the country. This method of building has now taken on the name of " Dorlonco." We illustrate this month (*see* Frontispiece) one of its most delightful achievements, a detached house at Petersham, Surrey. This house, which stands with its garage adjoining, is situated on the borders of Richmond Park. The district abounds in beautiful houses varying in age from 100 to 150 years with which this new erection will be in perfect harmony. The embellishments are few, and the decorative features scanty, yet, because the proportions are so good and because the ornament has been detailed with the utmost care, the result is so absolutely satisfactory. Note, for example, how the elevation gains by deviation from perfect symmetry, but it does so because the shutters of the sash windows balance the larger feature on the opposite side of the door.

HOUSES AT WALSALL.

Many local authorities in various parts of the country, finding that contractors' tenders are too high for acceptance, have decided to undertake the erection of their houses by means of direct labour, thus eliminating the contractor and saving his profits. Where such authorities are willing and able to give adequate safeguards, the Ministry of Health are willing to give their sanction to this arrangement. Where the houses are to be built of concrete the problem for the local authority is an easier one, since, presuming the aggregate to be on or near the site, the amount of material to be ordered and handled is less than in the case of a brick scheme. At Walsall, in Staffordshire, most of the houses in the Corporation's housing scheme are concrete. The town is situated near to Birmingham, where the housing shortage is acute, and the Corporation's scheme includes 450 houses, most of which are to be erected on one large site which stands high up on gravel soil on the north side of the town. The site has been laid out in such a manner that the density of the houses is low, about 9 to the acre, so that the Council's scheme will contrast very favourably with the adjoining overcrowded property. Each house has its garden and provision is made for open spaces and playgrounds. Attention has been drawn, in discussing former schemes, to the enormously enhanced amenities which are provided by most of the Government housing schemes, and in view of the amount of criticism to which

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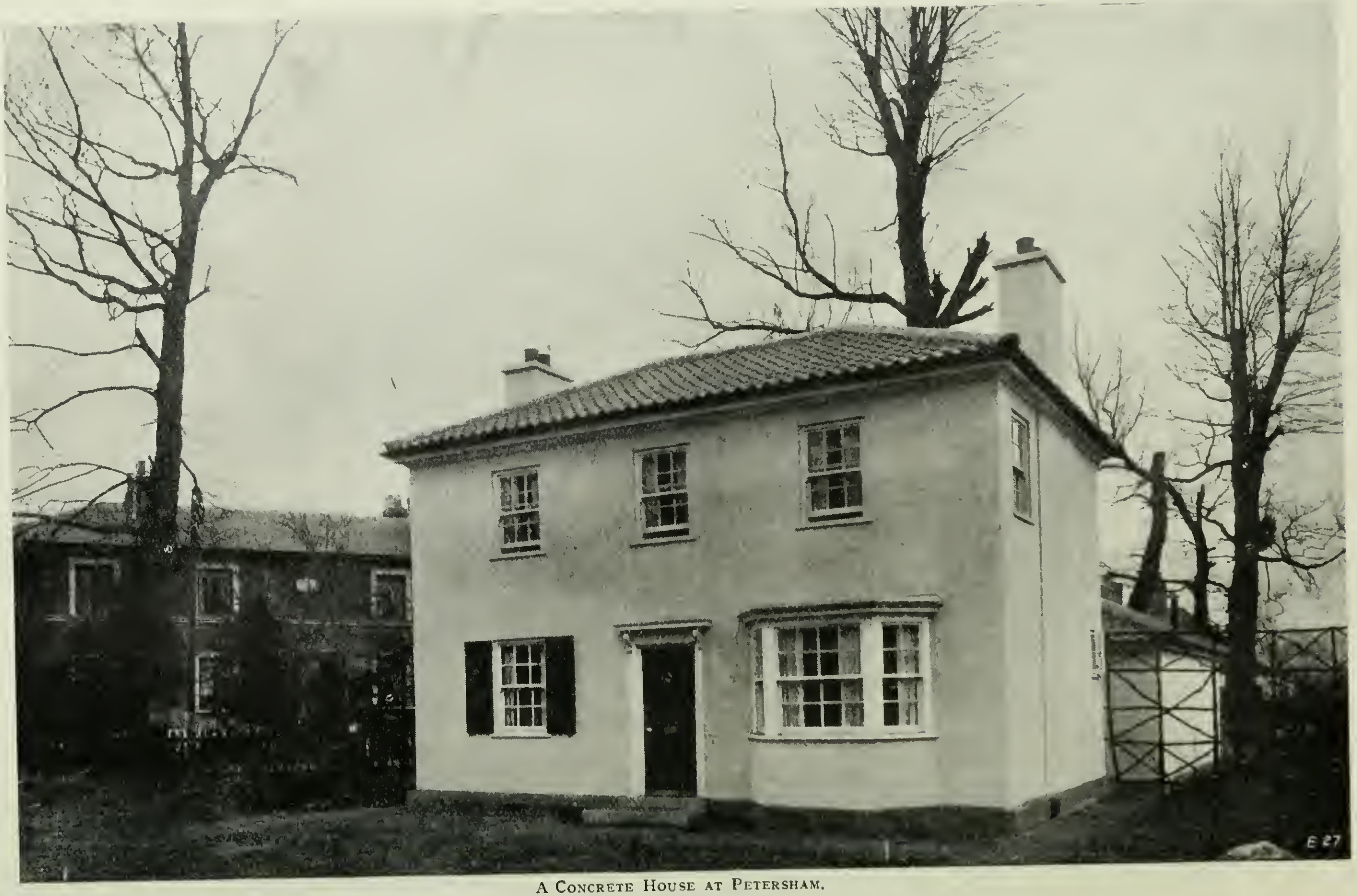


A Concrete House at Petersham.
(*For description see page* 152).

these schemes are sometimes subjected, it is only fair to point out that, even if in many cases the accommodation in the houses themselves leaves much to be desired, the long rows of sunless houses, overcrowded upon each other, with only the smallest and filthiest back-yard, is indeed a thing of the past.

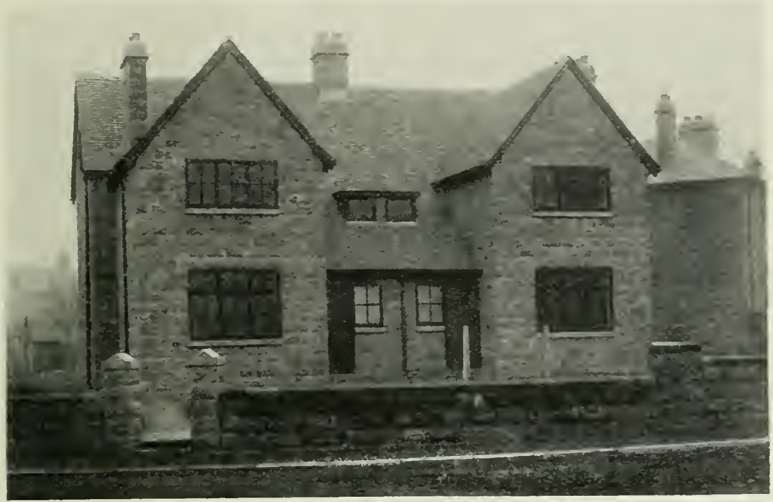


Fig. 1. A Corner Block.

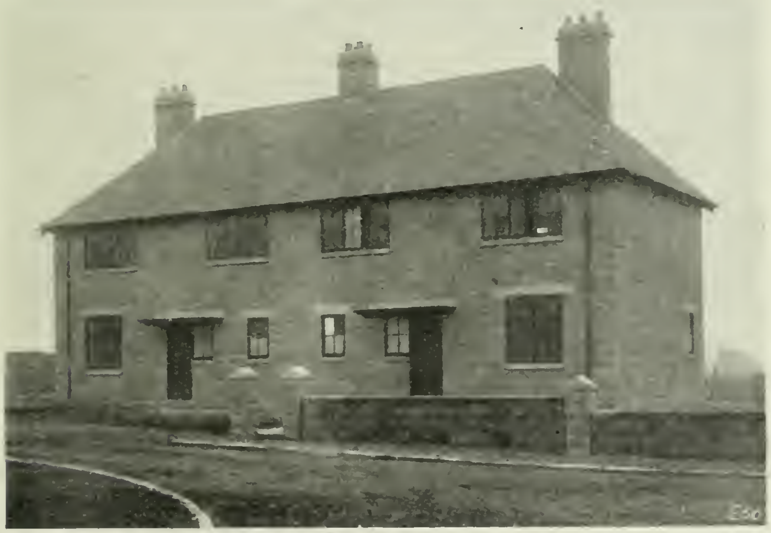


Fig. 2. A Completed Pair of Houses.

HOUSES AT WALSALL.

Work has so far been begun on 120 houses, and the job has been very thoroughly organised so as to economise in labour by Mr. J. Taylor, the Borough Engineer and Surveyor. Light railways have been laid to move material, and the Council are erecting their own joinery and machine shops. Twenty-four houses are actually completed, the majority of which are of concrete block construction. The blocks are made on the site with two 32 in. Winget standard machines which are served by one chain-spade concrete mixer. This machine is able to make all the blocks required, of whatever shape. The construction adopted is a continuous cavity system, the outer leaf is 3 in. in thickness and is made of sand and gravel aggregate with which is mixed a small quantity of lighter aggregate obtained from the Corporation's sewage farm. The inside lining is 4½ in. thick and is composed of equal parts of sand and fine ashes. It is to be regretted that the blocks were made with a rock face; we have had on former occasions to deplore this attempt to imitate stonework; a smooth-faced block, or one on which the face was brushed over while still green to show the pleasant colour and texture of the aggregate would, in our opinion, have been a more successful treatment. *Fig.* 1 shows a corner block of two houses; the grouping of the gables with the low sweep of roof in the centre is very satisfactory. In *Fig.* 2 is seen a house of simpler outline with a lower pitched roof.

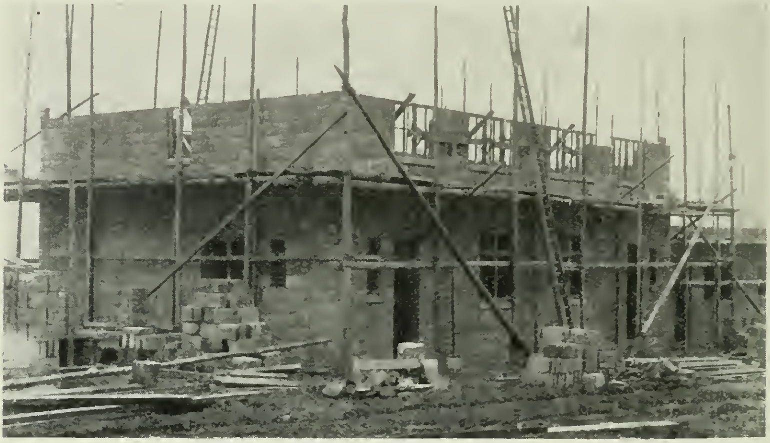
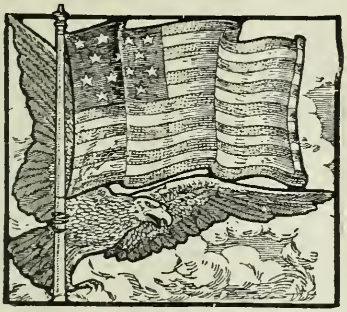


Fig. 3. Houses in Course of Erection.

About half the houses on the site are of the parlour type. Fortunately for the Council, owing to the favourable price at which they have been able to build, the original standards of the Ministry of Health have been adhered to; thus the living-rooms are the full 180 ft. super, instead of the reduced 160 which has now become the standard in parlour houses. Similarly, throughout, the sizes are generous, and the little extra fittings which help so much in the subsequent maintenance of the house have not been eliminated at the tender stage. Thus the living-room is provided with a large cupboard which, with two drawers and a table top, serves as a sideboard. A hot airing cupboard is also provided. Electric light is installed throughout complete with all fittings and is charged for at a fixed weekly price per lamp. The houses that are occupied are proving extremely satisfactory; there are no cases of dampness or of condensation. The price of the "B" type house has so far worked out at £837 5*s*. per house, but this already low figure includes paths and the boundary wall, and it will be observed from the illustrations that this wall is executed in an unusually substantial manner.

The whole scheme from its inception has been carried out by the Borough Surveyor with the aid of a staff of which Mr. W. H. Booth is the chief architectural assistant and Mr. S. G. Wilson the Clerk of Works.



CONCRETE HOUSES IN AMERICA.

It is perhaps as unwise to generalise about a country's architecture after perusing its architectural publications, as it is to assess its national characteristics from a few inhabitants who may visit these shores. The first impulse, however, after turning over pages of *Concrete Houses*, is one of admiration at the comprehensive and progressive manner in which the problem of building in concrete so that the material shall be used to its best advantage, both practically and æsthetically, has been, and is being, approached.

Concrete Houses * is published by the Concrete-Cement Age Publishing Company, Detroit, and contains, for the most part, articles that have appeared in the monthly publication *Concrete*. A statement of the difficulty that has to be met, and which is common to both England and America, is made at the outset so succinctly as to justify a somewhat lengthy quotation. " It is the outstanding fault of numerous houses of concrete that they are both uneconomical and unconvincing from an architectural standpoint, because they are frame houses or brick houses masquerading in another radically different material.

" When concrete is to be used, the designer should think in terms of concrete from footing to parapet. . . . Do architects and builders, as a class, never feel the need of new fields to conquer ? " Whether or no they feel the need, it would seem from the publication under consideration that new fields have been conquered ; it must be presumed, therefore, that such conquests are all too rare.

The work of Mr. Irving J. Gill is not unknown in England. Without a doubt he is one of the conquerors, for he realises the essential qualities of the material, and, bearing these in mind, produces a design which is both logical and beautiful : in *Fig.* 1, which shows a portion of a house from his design, the plasticity of the material is felt in the broad simple masses, and in the gently-rounded surfaces. Architects so often appear to be archæologists or ignoramuses, so that their work is either the dead bones of the past dressed in new shrouds, or the illiterate utterings of those who know nothing of architectural tradition or forms. If the best results are to be obtained with concrete a mean between these extremes must be reached. Scholarship and imagination are requisite qualities.

In England the most usual form of concrete construction is the concrete block. This is not so in America. The volume contains more examples of monolithic work than of any other form of construction, much of this, as has been indicated, is of a remarkably high quality. Where, however, the mechanical element predominates, the results are less satisfactory. Colonies of " poured " houses, identical in every respect, suggest a devastating monotony that it were well not to perpetuate. *Fig.* 3 gives an idea of the method by which this type of house is built. The forms consist of structural steel channels in standard sizes, with holes so located that they can be locked together securely by means of clips and wedges. The really essential feature of these forms is the string course detail which forms a 2-in. projection at each floor, and forms the foundation on which the shuttering for the next floor is placed. The houses are built of concrete throughout, and the walls are solid; the customary cavity is formed on the inside between the concrete and the plastering, which is fixed to studding. *Fig.* 2 shows the houses completed.

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* *Concrete Houses : how they were built.* By Harvey J. Whipple.

Another frequently-used system of construction appears to be by means of pre-cast members. An extremely interesting example of this method of building occurs at a settlement known as Forest Hill Gardens. *Fig.* 4 gives an idea of the possible scope of this method, which has hitherto been the subject of only tentative experiments in England. The illustration suggests a mediæval motif adopted to modern requirements:

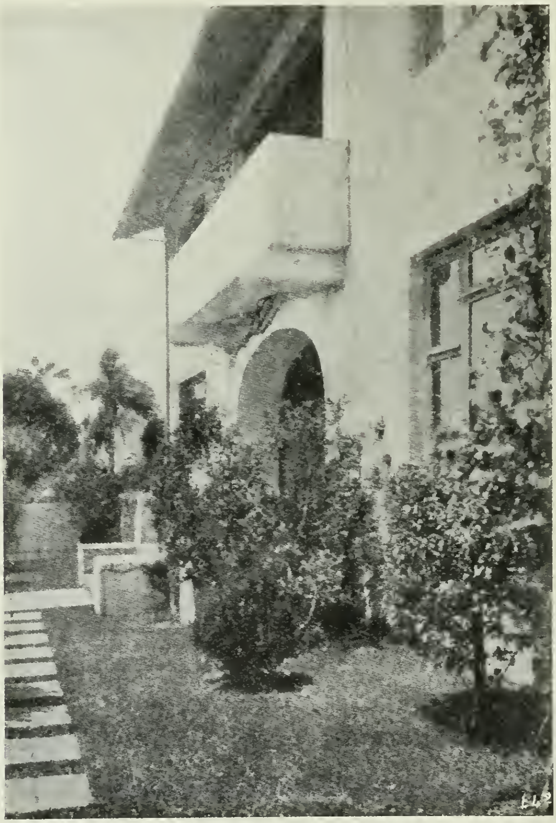

Fig. 1. A Concrete House in California.
Architect: Irving J. Gill.

the general arrangement and grouping certainly recall such towns as Rothenburg, but it is indeed no imitation. The whole work of building the settlement was carried out on modern manufacturing lines. The pre-cast members were made in factories. "From the casting-shed or head-house an overhead electric crane runs out through the storage yard, where wall, floor, and other sections are stacked ready for transportation on small cars running over an industrial railroad to the building site." The entire process from manufacture to erection seems to involve only three handlings. The walls between the pre-cast members are in many cases filled in with brick-work. Much of the aggregate for the concrete is composed of broken-roof tile, so that the colour and texture of the whole must be very beautiful. The architect is Mr. Grosvenor Atterbury.

A surprising fact about American work is the little precaution that seems to be taken against condensation. The usual method of dealing with the monolithic house has already been explained. The hollow wall seems to be regarded almost as a novelty. There would seem to be no example of the vertical sheet damp-proof course, although a section is shown of a monolithic wall which contains a porous block in the centre.

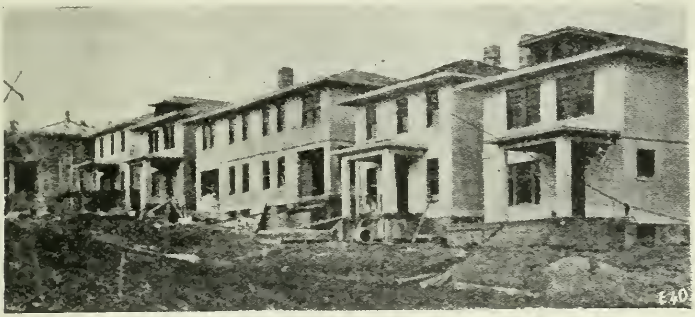

FIG. 2. GROUP OF MONOLITHIC CONCRETE HOUSES.

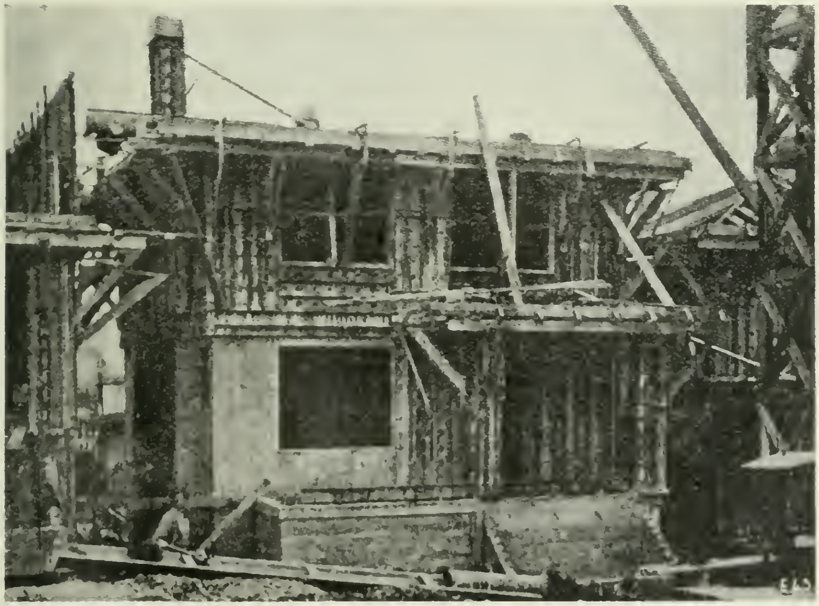

FIG. 3. MONOLITHIC CONCRETE HOUSE.

In England we are apt to allude with much frequency to our bureaucratic methods, and accuse them of hampering all progressive enterprises. It would appear that in one respect, at least, the English designer is less hampered than the American, by the passing of the Town Planning Act of 1919. Restrictive bye-laws have been rendered temporarily innocuous, and this has enabled work to be carried out in many districts that would otherwise have been impossible. The American architect does not appear to be so favoured, and but little discrimination appears to be made between the requirements imposed for the concrete factory or the concrete cottage, the entire structure in the latter case weighing perhaps only some 200 tons.

Reference has frequently been made in this Journal to concrete surfaces. It is, perhaps, in these more than in any other detail that American work excels. The volume contains many illustrations of various surface treatments, including subsidiary building ornaments, such as wall fountains, garden ornaments, and the like. It would indeed be no exaggeration to state that this volume should be in the hands of all architects and designers who are interested in domestic architecture, and if, perchance, some of them are as yet not awake to the problems of the day, or to the potentialities of concrete, the book may throw light where it be most needed.

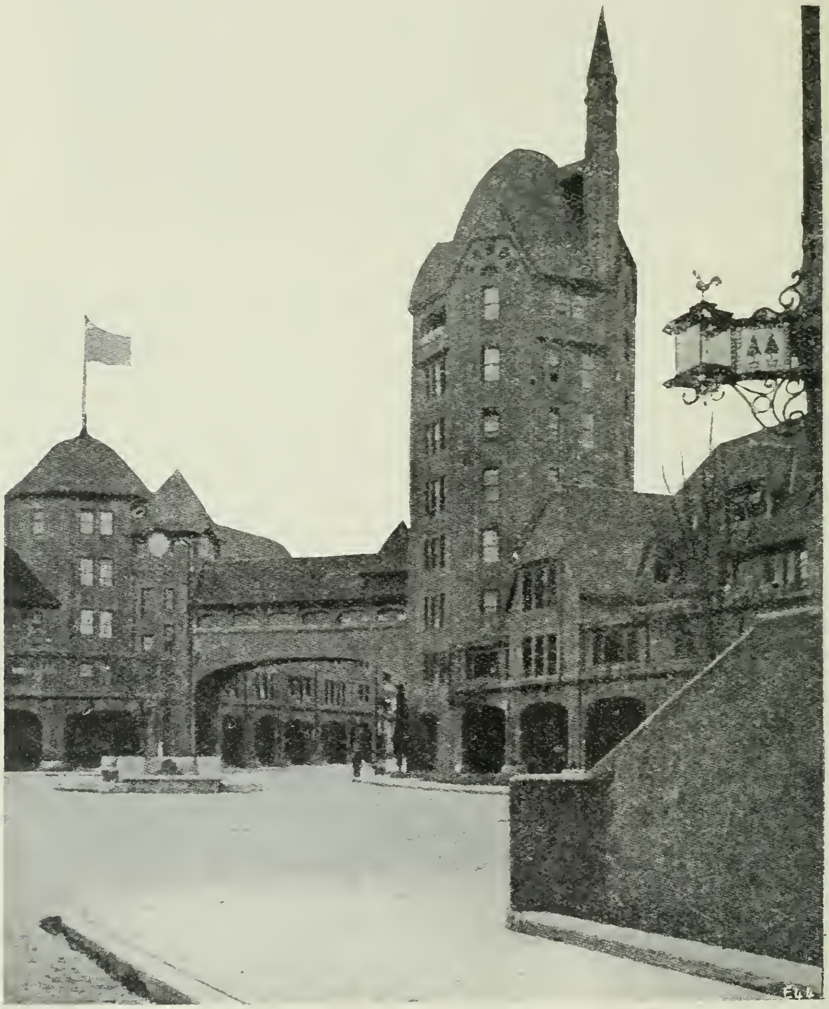

Fig. 4. Forest Hill Gardens.

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY

COUNCIL AND COMMITTEE MEETINGS FOR MARCH AND APRIL.

March 3rd.	R.C. Practice Standing Committee, at 4 p.m. Science Standing Committee, at 5.30 p.m.
,, 10th.	Literature Standing Committee, at 5.30 p.m.
,, 17th.	Finance and General Purposes Committee, at 5.30 p.m.
,, 31st.	Council, at 5.30 p.m. Ordinary General Meeting, at 7.30 p.m. Paper by Mr. Sven Bylander, M.C.I., entitled "Stresses in Structural Steel."
April 7th.	R.C. Practice Standing Committee, at 4 p.m. Science Standing Committee, at 5.30 p.m.
,, 14th.	Literature Standing Committee, at 5.30 p.m.
,, 21st.	Finance and General Purposes Committee, at 5.30 p.m.
,, 28th.	Council, at 5.30 p.m. Ordinary General Meeting, at 7.30 p.m. Paper by Prof. F. C. Lea, D.Sc., entitled "The Elastic Modulus of Concrete."

RECENT ELECTIONS INTO THE INSTITUTE.

Members :—	Bourne, Wilfrid Augustin Ranulph. Easton, William Cecil. Ellis, Philip. Glock, Arthur James. Green, Douglas Harold. Hobbs, Arthur Ernest. Holbrow, Alfred Ernest. Jardine, Henry Stringer. Kersey, Alfred Thomas John. Latham, Daniel John. Mackley, John Thomas. Mitchell, George Arthur. Shingleton, Leslie. Thain, Thomas Edward.
Associate-Members :—	Cramer, William (passed Examination). Harrison, John Lawrence Eagle (from Student). Huntley, Arthur Geoffrey. Loonba, Ram Lall. Morton, Harry (Graduate ; passed Examination for A.-M.). O'Connell, Terence Joseph (passed Examination). Roughan, James Joseph (passed Examination). Shore, Albert William (passed Examination).

Graduates :—
CLOKE, Cecil Jesse Witney.
CROWTHER, Fred Sefton (passed Examination).
JONES, Ernest.
SCHOFIELD, Reginald William (passed Examination).

Students :—
BERRY, Cecil Vernon.
CLAYTON, Arthur John Hamblin.

BUILDING TRADES' EXHIBITION, OLYMPIA, April 12th to 26th, 1921.

The Institute hopes to make arrangements for some lectures at the above Exhibition, full details of which will be published later.

NOTICE TO INVENTORS, PATENTEES, AND MAKERS OF SHUTTERING FOR CONCRETE WALLS.

The Concrete Institute is preparing a list of various kinds of shuttering for Concrete Walls ; and Inventors, Patentees and Makers of such kinds of shuttering are requested to send particulars to the Secretary, Concrete Institute, 296, Denison House, Vauxhall Bridge Road, Westminster, S.W.1, for inclusion in the list.

Descriptions should be as brief as possible, and the particulars will be edited, with a view to the deletion of all extravagant claims and all statements derogatory to the products of the vendor's competitors.

Illustrations can be printed alongside the descriptions, provided that blocks are supplied at the same time.

NOTICE TO MAKERS OF WATERPROOFING COMPOUNDS.

The Concrete Institute are enquiring into the claims made for various waterproofing compounds for concrete, and makers of such compounds are requested to send to the Secretary, Concrete Institute, 296, Denison House, Vauxhall Bridge Road, Westminster, S.W.1, a paragraph giving brief particulars of their compounds for publication.

CONCRETE AGGREGATES (*continued*).

SUPPLEMENTARY.

(18A) **Chichester (Sussex).—**

General description : Flinty gravel.
Source and Locality : Pound Farm, Chichester.
How obtained : Digging.
From whom obtained : The Pound Farm Gravel Company.
Is available quantity limited ? No.
Present maximum output per day : 50 tons.
Transport facilities : Road and Rail ; Water transport could be arranged.
Is there any provision at or near source for washing or crushing ? For washing.
Price at place of delivery : 8s. 6d. per ton in the Pit ; 10s. 6d. per ton on Rail.
Is composition uniform ? Yes, if required.
Shape of particles : Angular.
Size of particles : Any size from " sand " upwards, graded as required or mixed.
General remarks : The material is washed clean, and is used locally for the better class Concrete work ; but the major portion is being delivered by road and rail for use elsewhere. It is also much used for tar-spraying in the smaller sizes.

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* See issues commencing with August, 1920.

MAIN LIST.

(33) **Faringdon (Berkshire).—**

(i) *General description :* Pit gravel. (ii) Gravel and sand.
Source and locality : Local pits. Local pits.
How obtained : * Felling and digging.
Is available quantity limited ? No. No.
Present maximum output per day : Small, but could be increased. (ii) Not known, but large supply.
Transport facilities : One mile carting, thence by Rail. (ii) Horse and tractor or Rail.
Is there any provision for washing or crushing at or near source ? No. (ii) No.
Price per cub. yd., and where delivered : 3s. 6d. to 4s. at Pit. (ii) 3s. 6d. at Pit.
Is composition uniform ? Yes. (ii) Three classes.
Kind of stone or coarse material : (ii) Limestone local and gravel stone.
Kind of sand or fine material : (ii) Siliceous.
Relative proportions of coarse and fine material : (ii) 1 to 2.
Shape of particles : (ii) Angular as regards the large particles.
Size of particles : approximate percentage that needs crushing to pass $\frac{3}{4}$ in. screen Almost 50 p.c. (ii) 12 in. to 3 in. downwards.
Impurities present : (ii) Small amount of clay.
General remarks : (ii) Very commonly used, and ranks in the first class.

* No information supplied.

TESTS ON HIGH TENSION STEELS IN REINFORCED CONCRETE DESIGN.

By H. KEMPTON DYSON.

The following is an abstract from a Paper read at the Ninety-ninth Ordinary General Meeting of the Concrete Institute on Thursday, January 13th, 1921. An interesting discussion followed upon the reading of the Paper.

THE tests described in this Paper are the outcome of an agitation that has been proceeding over a period which commenced some years previous to the war.

Certain firms of reinforced concrete specialists had been selling special steels which they contended could be safely stressed to considerably more than ordinary mild steel. They had employed their reinforcements in works which they had designed, where they had adopted such higher stresses, but the then proposed regulations for reinforced concrete which were being formulated by the London County Council and submitted to the Local Government Board did not permit them to use such higher working stresses. This they considered to be unfair, and they protested vigorously to the various Technical Societies and in the Press.

The Joint Committee on Reinforced Concrete conducted by the Royal Institute of British Architects took notice of this contention in their Second Report and suggested that if stronger steel were used the allowable tensile stress might be taken at half the stress at the yield point of the steel, but in no case should it exceed 20,000 lb. per square inch. This, of course, should be compared with the figure of 16,000 lb. per square inch which they advocated as the working stress on mild steel, having an ultimate tensile strength of 28–32 tons per square inch.

The Concrete Institute was one of the chief bodies concerned with the criticism of the Regulations of the London County Council when they were in draft. They made the most suggestions for alteration, and their suggestions were largely adopted. They supported the contention of the specialist firms interested, and agreed with what had already been advocated by the British Joint Committee, in suggesting that for special steels, such as medium carbon steel and drawn steel wire, a working stress of 20,000 lb. per square inch should be permitted.

The officials of the London County Council and the Local Government Board, however, did not agree with this recommendation; and the Regulations, as finally approved, permit only of the steel being stressed to 16,000 lb. per square inch, and moreover they provide that the steel shall conform to the quality required by the British Standard Specification for steel for bridges and general building construction. This the firms interested considered to be grossly unfair by restricting proper improvement in engineering practice, and they protested to the Concrete Institute very strongly.

They were told by the officials that if they could get the Engineering Standards Committee to make a specification specially relating to their steel, permitting a higher stress to be used, the thing would be automatically taken account of in the Regulations.

On application, however, to the Engineering Standards Committee, they were rebuffed on the grounds that there was insufficient demand for their steel for it to be worth the while of the Engineering Standards Committee to draw up a special specification for such steels.

Eventually, as a result of the agitation, the Concrete Institute decided to appoint a special Sub-Committee which should report to the Council and upon which all those commercially interested would be represented, together with certain professional members considered to take a somewhat independent view.

This Sub-Committee was formed, and consisted of the following :—Messrs. J. F. Butler, H. Kempton Dyson, R. H. H. Stanger, B. Taylor, R. W. Vawdrey and T. A. Watson. The following were subsequently added to the Committee :—Messrs. A. L. Johnson, A. W. C. Shelf and H. R. White.

The writer of this Paper was appointed Chairman, and explained what had occurred at the Joint Committee meeting at which the representative of the Engineering Standards Committee and the Institution of Civil Engineers had expressed the opinion (in which some other members of the Joint Committee concurred) that it would be desirable to endeavour to settle the controversy by means of tests, which would be conducted by some independent body, and therefore would not be open to the criticism that they were made by the firms interested in marketing special steel. The Committee came to the conclusion, therefore, that it was desirable to conduct such tests in order to determine if the claims were really justified.

The specialist firms expressed their willingness to contribute to the costs of such tests.

After considerable discussion, it was thought best to conduct a preliminary series of experiments, which would give data that might serve as sufficient evidence to convince engineers generally, and the authorities in particular, or would serve as a basis to devise other tests, which could be witnessed by official representatives.

The discussion brought out certain opinions which it was desired to test, and two sets of experiments were considered necessary.

The first set consisted of a number of slabs which were to be tested with a point load at the centre. These tests had for their object to show whether steels of higher tensile strength than mild steel could be employed to give a greater moment of resistance than mild steel, without undue cracking by reason of the extra extension resulting from the higher stress. These tests were such as not to test the shearing resistance of the concrete.

The second series of tests were on beams in which the shearing resistance of the concrete was to be tested, it being thought by some that if special steels were used, which could be stressed higher than mild steel, the size would be correspondingly reduced, and with the diminution in the size of the reinforcement, the ratio of circumference to area would be increased, so that the adhesion would be similarly greater, and that this increased adhesion might reduce cracking, and so enable the concrete to resist greater diagonal tensile stresses, i.e., have a greater shearing resistance. In particular it was thought that where a number of drawn steel wires were employed the adhesion would be so much greater than where only a few bars of large diameter were used, that the concrete would not be cracked adjoining the supports, because the extra adhesion would enable the concrete to be stretched without cracking (an argument originally put forward by Monsieur Considére) so that the shearing resistance might be found to be thereby increased.

Series of slabs and T beams were designed to meet these theoretical views. In the first series mild steel bars were disposed in the slabs to compare with the special steel reinforcement. In the first case a slab was designed so that when the stress in the steel was 16,000 lb. per square inch the stress in the concrete would be approximately 600 lb.

In the second case the area of the steel was such as would develop 16,000 lb. per square inch, while the stress in the concrete was only about 550 lb. per square inch, that is to say, the area of steel provided was approximately twenty-sixteenths of the high tensile steels, the stress in the concrete being kept below the usual working stress of 600 lb. per square inch.

The special steels on the market were found to belong to three types, namely, those of

(1) Medium carbon steel, like " Indented " bars ;
(2) Cold worked steels, such as twisted bars ;
and (3) Drawn steel wire.

It was thought by some members of the Committee that it might be necessary in order to develop the higher stresses when employing medium carbon steel to have a continuous mechanical bond, such as was provided by the " indented " bar ; but it had been found during the war that the shell-discard steel permitted to be used by the Government for reinforced concrete work conformed more or less to this category, in that it was a higher carbon steel than ordinary mild steel, and had generally a greater ultimate strength. Therefore a set of tests was decided upon wherein shell-discard steel was to be employed, such steel bars being supplied by the firm rolling the " indented " bars, with a view to their being of similar quality material—the results of the tests seem to indicate that the steel furnished was not what was required. In the slabs, at any rate, it was more in the nature of mild steel, that is to say, it was exceptionally good shell-discard steel, and unfortunately this part of the inquiry failed, in that the steel was not as intended. In the beam tests the steel was not really tested in tension, but only the resistance of concrete in shear.

The steel was given free by the various specialist firms.

Mr. Stanger, one of the members of the Committee, most kindly offered to test the specimens in his testing machine, if the specimens were made for him ; but difficulties were met with in making the test specimens near to Mr. Stanger's works and in devising a means of getting them into his testing room, so that eventually it was decided to make the tests in Manchester, because at Manchester College of Technology they had an equipment for testing beams in a vertical position, which it was thought would be somewhat better than horizontally, as would be the case in Mr. Stanger's machine, but the Committee decided they would avail themselves of Mr. Stanger's kind offer to test the specimens of steel bars. This procedure was followed.

An estimate was obtained from a Manchester firm of contractors, namely, Messrs. Tinker and Young, for making the specimens on a vacant site adjoining the College of Technology.

The concrete was made in what was supposed to be the ordinary average manner, of the ordinary quality employed in buildings, for which the working stress adopted would be 600 lb. per square inch.

The Table, p. 164, gives the general data regarding the design of the test pieces. It shows working stresses under working loads.

It was anticipated that the tests would show a factor of safety approaching 4, that is to say, that the breaking load would be four times the working load given in the table. The loads stated in the table include for the deadweight of the specimen itself.

The detailed records of the tests indicate that the factor of safety shown for the slabs reinforced with mild steel rods was approximately 3·6, that is to say, the moment of resistance at rupture was 3·6 times the moment of resistance for which they were designed when the stress was 16,000 lb. per square inch.

This factor of safety of just under 4 has been evidenced in numerous tests on reinforced concrete beams, and we must therefore reckon that in practice we are really content with this factor of safety.

The test records show that if we are content with the same factor of safety for high tensile steels, then it would be right to design (as compared with the working stress of 16,000 lb. for mild steel) for working stresses of 22,000 lb. per square inch for medium carbon steel and 21,500 lb. per square inch for " twisted " steel bars, and 25,000 lb.

per square inch for drawn steel wire, of the respective qualities employed in these particular tests.

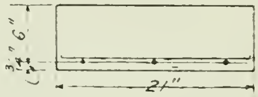
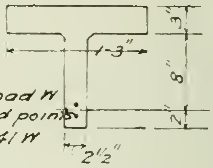
As regards the question of the deflections being greater, consequently the cracks larger, the tests show that the deflections were certainly greater, because, of course, the loads sustained by the beams were bigger ; but the tests bring out quite clearly, as is shown by photographs, that in all cases the increased stress developed in the steel did not result in larger cracks, but only in a greater number of cracks, therefore the argument, that by using a higher stress the steel would be exposed more to corrosion, falls to the ground.

CONCRETE INSTITUTE RESEARCH

Sub-Committee on High Tension Steel in Reinforced Concrete.

H. Kempton Dyson
Chairman

Test pieces 11'-0" long Span 10'-3"

Section of Test Pieces	Slabs				Tee Beams		
	 Test Load W in centre $B_t = \frac{Wl}{4}$				 Test load W at third points $B_t = 41\,W$		
Weight of Test pieces – w	1515 pds				748 pds		
B due to own weight – B_w	23 300 p.i.				11 500 p.i.		
Reinforcement	M S Bars		H T Bars	Drawn Wire	M S Bars	H T Bars	Drawn Wire
Size & N° of Bars	$3-\frac{1}{2}\phi$ & $1-\frac{9}{16}\phi$	$3-\frac{9}{16}\phi$	$3-\frac{1}{2}\phi$	$12-\frac{1}{4}\phi$	$1-\frac{3}{4}\phi$ & $1-\frac{13}{16}\phi$	$2-\frac{11}{16}\phi$	$10-\frac{5}{16}\phi$
A_t	·837 □"	·746 □"	·589 □"	·589 □"	·960 □"	·742	·767 □"
a	5·28"	5·3"	5·4"	5·4"	9·81"	9·9"	9·9"
t	16 000	16.000	20.000	20.000	16.000	20.000	20.000
c	594	550	600	600	565	595	605
R_t	70.700	63.500	63 500	63 500	151000	147 000	152.000
B_w	23 300	23.300	23.300	23.300	11.500	11.500	11.500
B_t	47.400	40.200	40 200	40.200	139 500	135.500	140.500
W	1538 pds	1306 pds	1306 pds	1306 pds	3 400 pds	3300 pds	3430 pds.
To double t add W_1	2296 "	2064 "	2064 "	2064 "	3.680 "	3.590 "	3710 "
At Load = $3W_1 + W$	8426 "	7498 "	7498 "	7498 "	14440 "	14 070 "	14560 "
S { $S = \frac{W+w}{2}$	12·1 p/□"	11·2 p/□"	11·2 p/□"	11·2 p/□"	13·7 p/□"	13·3·5 p/□"	13·8 p/□"
$S = \frac{W_1}{2}$	9·12 "	8·2 "	8·2 "	8·2 "	13·4 "	13·0·5 "	13·5 "
$S = \frac{3W_1+W+w}{2}$	39·4 "	35·8 "	35·8 "	35·8 "	54·0 "	52·6 "	54·3 "
Adhesion { $S = \frac{W+w}{2}$	44·6 "	50·4 "	55·5 "	27·8 "	78·5 "	86 "	39·2 "
$S = \frac{W_1}{2}$	33·5 "	36·9 "	40·6 "	20·3 "	76·4 "	84 "	38·2 "
$S = \frac{3W_1+W+w}{2}$	145 "	161 "	177·4 "	88·7 "	308 "	338 "	154 "

As regards the tests on the **T** beams, the writer thinks that these failed to show any of the supposed advantage that there might be in the smaller sizes of reinforcement. That is to say, the test results do not appear to show any increased resistance to shear even when drawn steel wire was employed. The failure occurred very nearly as was originally estimated.

The writer would like to add, however, some personal observations of his own, for which, it must be clearly understood, the Committee accept no responsibility. He hopes that these tests may be accepted as sufficient evidence by the Societies, London County Council and the Ministry of Health, to warrant the sanction of a higher working stress for special steels without putting the firms and others interested to further expense, because these tests have meant a considerable expense, both of money and of time and they appear to be pretty conclusive.

The tests on the slabs bring out clearly certain points which have been noticed in other tests and serve to illustrate a point which the writer desires to emphasise. It has long been argued by practical exponents of reinforced concrete design that slabs, as commonly designed and constructed, are one of the strongest parts of reinforced concrete construction, and that as regards their compressive resistance, they are much stronger than theoretical calculations would indicate, that is to say that a much higher percentage of steel could be employed without failure of the concrete. Evidently, if this is so, the determination of the stresses in the concrete is in error. The primary difference is probably due to the efforts of certain academic engineer professors, who have studied the works of elasticians, and have for some decades advocated the design of beams for working stresses, such working stresses being reduced by dividing the ultimate strengths of the materials by a factor of safety, instead of following the procedure of the earlier engineers—practical men who did an enormous amount of construction and obtained their knowledge from actual experience ; such older engineers experimented to find the ultimate resistance of beams and other parts of structures, and then adopted as the working load for such members a load which was obtained by dividing the ultimate resistance by the factor of safety. It is very difficult to determine what are the real stresses in the material at intermediate stages in the loading of such tests as have here been described, but the conditions at the point of ultimate failure are more readily ascertained.

It will be familiar to all students of reinforced concrete that in the formulæ which are commonly used there is a factor introduced called the modular ratio. This is supposed to be the ratio between the modulus of elasticity for the steel and the modulus of elasticity for the concrete. The tests on these materials show that the modulus of the concrete is continually changing, getting less as the stress increases, whilst the modulus for the steel drops very considerably when the yield point is passed, and with cold worked steels there is no well-defined yield point, so that there is no well-defined modulus. It is really not necessary to introduce the modular ratio into the formula at all, and it is suggested that it would be far better to abandon this mysterious variable and calculate always for probable ultimate resistances of beams, and then divide the resistance by the factor of safety, in order to obtain the working load.

All our data regarding reinforced concrete beams are derived from tests, and we know very little about what happens at intermediate stages of loading as regards the real stresses in the beams, but we know something definite about the point of failure. If we make our calculations for the ultimate resistance, we shall have to abandon the triangular stress strain distribution for the compression in the concrete and adopt some such figure as an ellipse or a parabola. Personally, the writer favours the ellipse as a nearer approach to the truth. The fact that the stresses are distributed more like the ordinary ellipse in the compression area of the beam accounts for the fact that one can put much more than the usual percentage of steel in slabs or rectangular beams without causing failure of the compression.

These tests illustrate what other tests have done, that as the load increased, the cracks at the centre crept up higher and higher, until the stress passed beyond the yield point of the steel and the steel began to extend considerably. The crack then extended so high that the portion of concrete left to carry the compression was so small that the concrete had to be ruptured. In all these tests the steel was never broken. It was the concrete which failed, and yet by estimating an approximate lever arm, one can calculate that the stress in the steel was so great that it was the steel that really was the primary cause of failure. There was plenty of concrete to enable the steel to be stressed well beyond its yield point. The fact that the bars were well hooked at the ends probably enabled the yield point to be exceeded considerably, though it has been contended by some investigators in the past, who did not properly anchor their steel, that the yield point was the critical factor and that when the yield point was reached the beam was bound to collapse. By their argument, the factor of safety in reinforced concrete was about 2 to 2½, and consequently some engineers thought that in order to ensure a proper factor of safety of 4, a working stress of about 10,000 lb. per square inch on mild steel should be adopted.

Of course the shifting of the neutral axis up towards the top of the beam is indicated by the ordinary theoretical formulæ if only we remember that when the stress in the steel passes the yield point, the modulus in the steel drops very rapidly, while if the concrete is not failing the modulus is dropping much less rapidly, the result therefore being that the modular ratio decreases ; and if in the ordinary formulæ we insert a lower value for the modular ratio, the position of the neutral axis is found to be much nearer the top of the beam. It seems to the writer a matter of importance to get a method of calculation which is precise from a mathematical point of view, yet is at the same time practical. It is a subject which he hopes to deal with again in a more detailed manner.

DISCUSSION.

The Chairman read a letter from Dr. Oscar Faber, O.B.E., etc. in which the writer referred to the fact that of course high tensile steel has been known to engineers these last ten years, and yet many of them had decided not to use it or, at least, not to stress it higher than mild steel for what he, the writer, considered good reasons. He was aware that it had been used in several places where there was vibration without serious disadvantage, but the steel used in those cases was an expensive alloy and the cost of same would have put it out of court for use as reinforcement. There was a two-fold danger with high tension steel.

(1) The writer's experience, and that of other engineers, was that that quality of high tensile steel which has been commonly available for reinforcing has only been bent cold with considerable risk of fracture.

(2) High tensile steel of the quality available for reinforcing is much more liable to become crystalline and brittle with vibration incidental to many types of structure than ordinary mild steel.

It would, therefore, appear to be a matter of common precaution to ask for a higher factor of safety on this material to provide against this risk of collapse due to the material becoming crystalline. Dr. Faber stated his own attitude in the matter has been—while not objecting to the use of high tensile steel—strongly to resist stressing it to higher stresses than he would be willing to use for mild steel.

The writer was of course aware of tests made and the results obtained, and also of the fact that excellent steels are manufactured to-day, which give higher tensile stresses without loss of ductility, but such steels are dearer than commercial mild steel. When we confine our attention to the actual high tensile steels which have been used by firms selling patent bars, it is undeniable that their use has been accompanied by indications that their behaviour, when bent cold, and subsequently, was likely to involve some risk as compared with the use of mild steel. Dr. Faber went on to say : " Personally, I should consider the well-being of the community would suffer in a risk of collapse of a greater proportion of concrete buildings than at present if the use of high tensile steel is permitted without greater safeguards to the public as to quality—particularly ductility—than is asked for at present with mild steel." The writer said he was, of course, not unsympathetic to the use of better materials in the future and taking full advantage of their properties.

In the last paragraph of his letter Dr. Faber referred to those steels in which additional strength is obtained by a twisting or other kinds of treatment other than chemical compositions, and he said that the raising of the yield point in these bars is lost when they are heated to a dull red heat.

Other disadvantages to high tensile steel are to be found in the greater number or size of hair cracks which will be produced on the tension side of members.

Mr. A. W. C. Shelf said he was an advocate of a higher stress being taken for high tension steels. He was not an advocate of a high carbon steel, because you were more likely to get crystallisation with a high carbon steel than with a cold worked steel. But a high tensile steel, a cold worked steel more especially, he was a strong advocate of. He was also in favour of high tensile steel as wire, but that might work out slightly uncommercial at the finish. He agreed with Mr. Dyson that the modulus of elasticity was more or less a theoretical bogey. With regard to some remarks in Dr. Faber's letter, the subject of cold worked steel and twisted bars was not in the state that it was when he (the speaker) took it up twelve years ago. At that time there had been tremendous failures. The application of a square twisted bar was entirely wrong for reinforced concrete. By cold twisting a round bar you got a higher efficiency than with a square bar. This question of cold twisting had become a scientific study ; up to a certain point the process built up the structure of the steel, but beyond that point the particles were cracked or fractured by it. For twelve years now buildings had been going up in this country where there were stresses of 25,000 lb. on the square inch of steel, and there had been no failures ; in fact there were records to prove that everything had been highly satisfactory. The only thing you were likely to get with bars of this kind was, perhaps, more numerous hair cracks instead of the lesser number of cracks you got with a mild steel.

Mr. J. F. Butler, A.C.G.I., A.M.Inst.C.E., said the tests had brought out results, as far as steel wire was concerned at any rate, which had long been known to the manufacturers of steel wire reinforcement. He was glad of this official confirmation—because he hoped it would be considered as an official confirmation by the Concrete Institute. He thought Mr. Dyson had been himself surprised at the results of the tests, but those who had been manufacturing were not surprised, because they had made similar tests themselves and had got exactly similar results. It was customary for manufacturers of steel wire reinforcement to stress up to 25,000 lb. That stress was regularly used outside the area of the London County Council and those areas which had followed the London County Council's regulations; and in one or two cases it had been used inside the London County Council's area. Dr. Faber in his letter had brought forward the old bogey that slabs reinforced with high tensile material were objectionable, because of the cracks. It used to be said that you got larger cracks, but these tests proved that the cracks were not larger. They might be larger in total extent because there were a larger number of them, but he thought a large number of small cracks was not so objectionable as a small number of large cracks.

Mr. H. R. White said that he represented an American firm interested in the sale of steel bars and wires, and that when he informed his principals that these tests were to be made they had expressed surprise that further tests were necessary. They felt that tests had been done to death; but he had pointed out that the authorities here were very conservative and put no faith in tests made by manufacturers, or in tests made abroad, even if these were made by technical institutions with no commercial interests to serve. Tests made abroad on high tensile wire, had hitherto been made on fabrics only. In actual practice wire was likely always to be used in a fabric, and therein were several advantages. The fabric ensured that the amount of reinforcement specified was there; but if you used bars of any kind they might be displaced, or, if the supervision was not what it should be, they might not be there at all. But any one could see whether a fabric was there.

Mr. B. Taylor, M. Salford Eng. Assn., said he had been interested in tests carried out for a period of about fifteen years—from the first instigation of reinforced concrete. These had been both bar and slab tests, and, like the tests described that evening, they had all gone to prove that the basis of the old R.I.B.A. formula, under which work was being done to-day, and which was in principle incorporated in the London County Council Regulations, was quite right; but that modification was needed in details. As to Dr. Faber's remarks about high tension steel being brittle and uncertain—for that was what it amounted to—they referred more to the shell steel that had been about during the war. This was a very high carbon steel. It had high tensile strength and a very small elongation; what was needed was a medium carbon steel with medium elongation. He thought that for columns high carbon or high tension steel did not give the same advantages as for beams. Unless it became recognised as an everyday commodity, as mild steel had become, its cost would very often take away all its advantages; so long as it was something special it would command a special price. But this matter would right itself if medium carbon or high tension steel was recognised by engineers to have decided advantages, and the rolling mills put down plant and laid themselves out for making it by mechanical process. With regard to steel wire the material was consolidated by the drawing; its density was intensified, and it was this fact that gave it its mechanical strength. It was quite usual to stress it to 25,000 lb.

Mr. P. G. Bowie said he thought the question rested mainly on the structures that had been put up. The whole thing was so variable you could not compare one case with another. If you took, say, 25,000 lb. with wire, what moments and that sort of thing did you take?

Mr. Ewart S. Andrews, B.Sc. (Eng.), M.C.I., said although he thought there were certain safeguards to be kept in mind in the use of high tension steel, he had always opposed any attempt to prevent its use. He objected on principle to any material being ruled out of court merely by a regulation in the absence of any definite reason for ruling it out. The principal objection raised against high tension steel was that it was brittle. But it need not be brittle, though, if we were to use it, great care was needed in manufacture and supervision. He had had an experience of high tension steel which was stressed up to 21 tons to the square inch and was perfectly satisfactory, and each article made from that steel was put to a second test of, he thought, 32 tons to the square inch; and he had not the slightest doubt that, if the people interested in the production of steel bars or steel beams would take the trouble, a medium carbon steel could be produced with an ultimate strength of 37 to 40 tons per square inch—with the necessary tension and ductility. If the steel was not brittle he saw no reason why it should not be used in concrete, or why, when so used, it should not be used to a stress commensurate with its yield point. If the present document did not convince the authorities, the next thing he would like to see would be tests to show whether the same comparative effect was got by drop tests on the slabs. Without attempting to prophesy, he thought that slabs made with the same high tensile steel as in these experiments would show as well under the drop test as with the static test. A more difficult point was as to what would happen if there were fire in the building and the steel was heated up to its critical temperature and softened. This was a real danger, but it was quite easy to make provision for the stability of a building to be reconsidered if a fire had taken place in it. A point had been raised with regard to ultimate strength and working stress. In cases where our existing knowledge did not enable us to proceed actually on theoretical calculations, he was quite willing to be guided entirely by tests—in fact it would be foolish to do anything else. But directly you started basing your work entirely on tests you never knew to what extent the test that you were being guided by fitted in with the conditions you were designing for. Another point was that every time you went past the yield point of steel you altered its character, until ultimately you could make it quite brittle; so that the same conditions did not hold after the yield point had been reached.

Mr. W. J. Pickering said he was not clear why modern engineering practice had not been followed in ascertaining the tiring value of the different kinds of steel. This was a common practice in the north of England. Another thing was, why should we perpetually test concrete in tension and not in compression? It was obvious from these tests that it was the compression which was of account.

Mr. E. Lawrence Hall said that even in London he had come across cases where 25,000 lb. had been claimed to be used, and had actually been allowed.

Mr. P. J. Black, District Surveyor for Wandsworth East, said that of course work done in reinforced concrete in London was not necessarily done under the Reinforced Concrete Regulations. As to the modulus of elasticity, was it not the fact that America, and Germany before the war—and possibly now—had a different value from ours?

Mr. Allan Graham, A.R.I.B.A., said he disagreed with a remark that had been made that high carbon steel was not suitable for columns. A great many reinforced columns had eccentricity, and the high carbon steel would be of great assistance in reducing the amount of steel required, or reducing the size of the concrete core. The tests had demonstrated conclusively that at any rate steel wire was able to do its work.

The Chairman, Mr. E. Fiander Etchells, said he would like to remove one or two false impressions; one was as to the Regulations. These were not made by any single individual whatsoever; they were made by the County Council after holding many meetings. The Council was guided by its officers, who in turn had consulted expert committees. Regulations which were come to by many minds and not by any individual mind, must come to a centre of gravity of opinion rather than be ultra-progressive or ultra-conservative. But the purpose of having Regulations was so that these could be altered more easily from time to time than an Act of Parliament could be. When the time was ripe, possibly before it was ripe, the necessary steps would be taken for the amendment of the Regulations. One speaker had said that we should not be prevented from using high tension steel from the fear that after a fire the building would not be so strong as it had been previously. But this consideration had not weighed with any one he was personally acquainted with. Fire had been regarded as an accident to the building, and not as something which should govern the construction of other buildings. Another matter was that there had been no ruling out of high tension steel by those who made the Regulations—it was specially provided for. There was one matter in which he was really very sympathetic with the authorities, and he believed his audience would be sympathetic too when he explained the point. In the case of reinforced concrete there was a question whether the formulæ for construction should be based on the elastic limit, the yield point or the ultimate stress. There were these three methods, and whichever one you selected you might be sure the partisans of the other two methods would trounce you. Mr. Dyson had expressed the hope in his paper that the tests might be accepted as sufficient evidence to warrant the sanction of a higher working stress for special steels. But there had been no representatives of building authorities or Government Departments present, nor of the other technical institutions that must be consulted. Another point was that Mr. Dyson had suggested we should abolish the modular ratio and base our calculations on the lever arm, because the modular ratio was a little uncertain; but he had gone on to say that the last reading always destroyed the last crack which told where the lever arm was. We should never reach perfection.

Mr. Dyson then replied to the discussion. Dr. Faber, he said, talked about shock, and the fact that bars had broken off short when being bent. That happened with mild steel as he (the speaker) had seen many a time; it depended on the kind of bending machine for one thing. Of course there were brittle bars; of shell discard bars some were rotten, some extremely good. He had had some tests carried out that showed that shell steel had greater ductility than the ordinary mild steel of pre-war days. Some of the mild steel sold in the form of ordinary rounds was really cold worked steel. He knew one rolling mills where, when the smaller bars were rolled, the steel got so cold that it was really cold worked steel; if you tested the bars made there from the same lot of steel the bigger bars would be found to have less ultimate strength than the smaller bars. The arguments about what happened when you shocked a piece of cold worked steel made him think such critics had never been in a rolling mill. Just to illustrate his point he would like to tell them of a visit he had paid to one of the largest rolling mills in the country some time ago, when there happened to be a strike on, so that he had the opportunity of seeing a good deal more than usual. Some very large section **I**-beams had been stacked while hot. Long lengths had been laid on the flat (on their sides) on top of short lengths; so that there was a pile of short lengths several feet high, and long lengths laid on them with ends overhanging. The long beams had been laid there when red hot, and the ends had bent right down—a tremendous bend. Did any one think those beams were put into the melting pot again? No. Round the corner were presses which all rolling mills had for straightening steel beams. This straightening is done cold; that is the steel is cold worked, and enormously so when such great bends are taken out as in the large beams referred to. Yet railway engineers were content with the ordinary mild steel of commerce; convinced that it would stand any amount of shock in railway bridges. But they did not know what it goes through in the works. It was all nonsense to condemn cold worked steels simply because they had been cold worked and because there had not been enough shock tests of them. He thought himself that 22,000 lb. as a working stress for special steel bars and 25,000 lb. on drawn wire would be quite proper practice. Mr. White had referred to the advantages of fabric and had said that drawn wire was not likely to be used for beams. But he (the speaker) had some years ago brought to the Concrete Institute a scheme of a German manufacturer for using drawn wire in beams. It was made into a sort of bundle which enabled it to be inserted readily into the reinforced concrete beams, and the firm got special advantages from the German Government in the design. Mr. Andrews had spoken about the yield point as being the limit from which we should get the working stress and the factor of safety; but it had been pointed out in the paper that in cold worked steels like drawn wire and twisted bars there was no well-defined yield point. If you stretched steel you created a new yield point, and you could stretch it again and create another yield point; but it was unlikely in practice that you were going to get beams continually loaded more and more in a crescendo so as to keep on stretching and getting fresh yield points throughout the existence of the building. Mr. Pickering had referred to the fatigue of metals. Certainly there ought to be a lot more research work, but there was great dispute about the fatigue tests that had already been carried out; papers had been read about them, and in all cases it was a great question whether you had purely fatigue or, in large part, impact. He (the speaker) thought the effects noticed were largely attributable to impact; if you compared the values in fatigue tests you would find them to be very similar to the effects of impact. Mr. Etchells had talked about the official mind. Experts in logic could be found to demonstrate that two and two made two under certain conditions; but ordinary people said it made four. He (the speaker) supposed that the official mind would take the consensus of opinion, and would decide that two and two made three-and-a-half. It should be up to the officials to take the best opinion, and to judge what was most correct; not to take a sort of average. Mr. Etchells had also talked about the lever arm that it was proposed in the paper should be substituted for the modular ratio; it was easy to calculate the lever arm. Mr. Etchells had also said that perfection would never be reached; but because perfection could not be reached in these tests, that was insufficient reason for taking no notice of them.

The Chairman added a few further remarks and the meeting terminated.

PORTLAND CEMENT.

ITS TESTING AND SPECIFICATION—BRITISH AND FOREIGN METHODS.

By R. E. STRADLING, M.C., B.Sc., A.M.I.C.E., A.M. Am. Soc. C.E. (Lecturer in Civil Engineering University of Birmingham).

I. Essential Properties of a Cement from the Engineer's Standpoint.

The writer considers that the essential properties which a cement must possess to be of use to the engineer are three :—

(1) Setting time within workable limits.
(2) Soundness; i.e. no disintegration with ageing.
(3) Strength sufficient for requirements.

(1) **Setting time.**—When a cement is mixed with water the mix gradually becomes stiffer until ultimately it sets into a hard mass. It is realised that probably chemical action is taking place from the moment the water reaches the cement grains, and that to develop the full strength of adhesion between two grains they should not be interfered with in such a manner as to disturb this chemical action. Owing to the impossibility of hydrating a large number of grains simultaneously, it is necessary to disturb the mass, by mixing, in order to cause the water to reach as much of the cement as possible. The chemical action causing "setting" must, then, from practical considerations, be interfered with, and the engineer requires to know the limit to which it is safe to carry this disturbance. It will be shown later how the chemical action can be demonstrated by measurement of thermal changes, but for the present note, it is only necessary to realise that certain arbitrary limits are used, though these would appear to have a certain relationship to the chemical changes taking place.

It is usual in modern practice to consider that a mixed cement should not be disturbed after a point at which a needle 1 mm. sq. in section just fails to penetrate a block 4 cm. thick. This point is known as the *Initial set.*

It is suggested that a cement which has an initial set of under one hour should be avoided in modern reinforced concrete work. During this hour the cement (in concrete) has to be mixed, taken to its position, then rammed round reinforcement. Then it is further disturbed by the ramming of the next batch of concrete. The term "*Final*" set is also used and is defined in the British Standard Specification in such a way as to be equivalent to the point at which the penetration of the 1 mm. needle does not exceed 0·5 mm.

(2) **Soundness.**—This term has a special meaning in connection with Portland cement. It has been found, that after certain cements (used in concrete) have been in position in a structure for some time, the mass starts expanding, causing disintegration. This action is known as "Unsoundness."

(3) **Strength sufficient for requirements.**—By far the greater proportion of cement used is utilised for concrete. That is to say its function is to "stick" the stone and sand together. Hence the essential "strength" requirement of a cement is a high "cementitious value."

II. THE SPECIFICATION.

The specification of a cement then, must so define its nature and properties that the preceding three points are assured if a product satisfies the tests laid down. The essential requirements of the tests to be enforced appear to the writer to be summarised as under :—

(*a*) Shall give a real indication of the suitability of the cement for the work in hand.

(*b*) Shall be independent, as far as possible, of the personal equation introduced by the one performing the tests.

(*c*) Shall be capable of indicating the quality of the cement in the shortest time possible.

In general the tests laid down in a specification must also be considered from two standpoints :—

(1) Are they such as can be easily performed in the works ?

or (2) Are they such as can only readily be performed in a laboratory ?

It is the intention of the writer in the following pages to indicate the problems he considers to be involved in measurements of setting time, soundness and strength, to consider the various tests used in Britain, the United States of America, France and Germany for the testing of cement, and to show to what degree the various specifications really conform to conditions laid down in (*a*), (*b*) and (*c*) above.

Before, however, any detailed tests are examined, it is first necessary to consider the general problem of the mixing of a cement with water, i.e. the general problem of hydration.

III. THE HYDRATION AND MIXING OF PORTLAND CEMENT.

The actual amount of water required for the chemical actions of "setting and hardening" varies with each sample of cement, but is in the neighbourhood of 9 per cent. by weight of the cement used.

It is not possible to mix a cement with this small amount of water and from two to three times the amount is required.

Within possible working limits the least amount used the better from the strength standpoint, providing the setting time is sufficiently delayed to allow of prolonged mixing, when small quantities of water are used. A very convenient method of seeing the amount of hydration in a mixed sample of cement is provided by the microscope by a similar procedure to that employed in the examination of metals.

Figs. 1 and 2 show photo-micrographs of cement clinker from a rotary kiln (× 100). The specimen was polished and etched and viewed by vertical illumination.

Fig. 3 shows a photograph of cement clinker from a stationary kiln (× 100).

It will be seen that the structure shown is very definite and quite easily recognised. The dark portions are usually termed "Alite" and the whiter matrix "Celite."

Fig. 4 shows a hardened cement pat (21 per cent. water) which has been *polished* and viewed in a similar way (× 100), the white portions being unchanged clinker.

Fig. 5 shows a similar pat but mixed with 23 per cent. water.

Figs. 6 and 7 show *polished and etched* specimens from a pat of mixed cement in which the clinker formation is easily seen. Quite large proportions of untouched clinker are present, that is to say the whole mass has not been hydrated. With a normally ground cement one of the original investigators of this (E. STERN) gives 50 per cent. as a figure commonly found in neat cements. In cement used in concrete this may increase to 70 per cent. (N. C. JOHNSON). This may explain the fact that if old concrete be re-ground to powder, the latter is found to possess some cementitious properties. It is considered that finer grinding may help to give a larger hydration ratio as the smaller the particles are ground the greater the area exposed to the action of water when any given weight of cement is used. It is probable * that the centre of cement grain is never reached by water even after many years of exposure in the mass.

* Desch, *Chemistry and Testing of Cement*, p. 118.

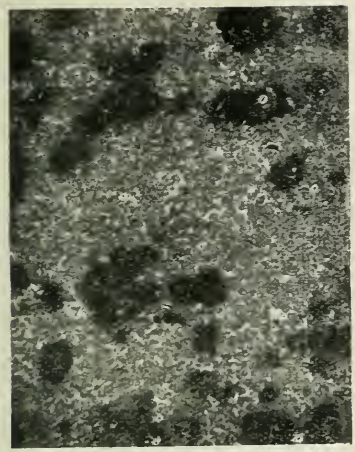


FIG. 1. ROTARY KILN CLINKER × 100 (v 1).

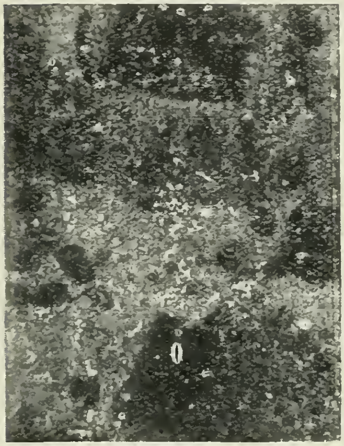


FIG. 2. ROTARY KILN CLINKER × 100 (v. 1).

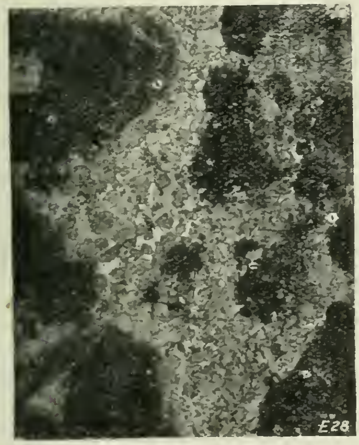


FIG. 3. STATIONARY KILN CLINKER × 100 (v. 1).

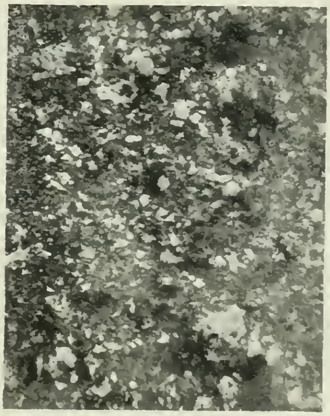


FIG. 4. CEMENT PAT (21% H_2O). (STRENGTH 638 LB. AT SEVEN DAYS.) POLISHED × 100 (v. 1).

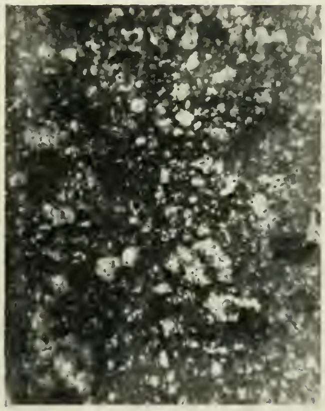
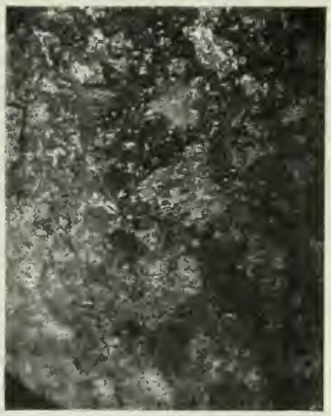


FIG. 5. CEMENT PAT (23% H_2O). (STRENGTH 565 LB. AT SEVEN DAYS.) POLISHED × 100 (v. 1).

NOTE: The photo-micrographs (*Figs.* 1 to 7), for purposes of reproduction, have been reduced to two-thirds the original size in each dimension, so that the amount of magnification expressed in diameters is reduced in the same ratio.



* Fig. 6. Cement Pat. Polished and Etched × 100 (v. 1).

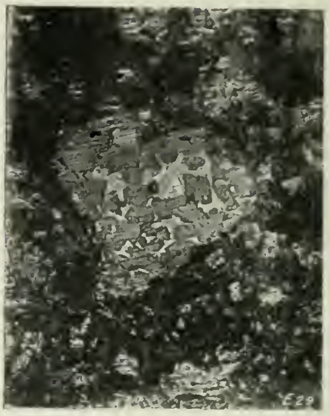


Fig. 7. Same as 6 but magnified to × 300 (v. 1).

It seems obvious from this that every means possible should be used to increase the proportion hydrated, as the unhydrated areas might more cheaply be filled by sand.

This hydration is apparently effected by four things at least :—

(1) Fineness of grinding.
(2) Manner and amount of mixing.
(3) Amount of water used.
(4) Temperature of water used.

In testing, (1) is already fixed, and does not enter into the problem. The real difficulty is to define uniform methods for (2) and (3). In following through the various specifications these problems will be discussed more fully.

Mixing Rules.

The Rules laid down by the authorities for the mixing of cement for standard tests are as follows :—

TABLE I.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

Mixing Rules.

British.	Mixed by hand with ordinary gauging trowel.
U.S.A.	Mixed by hand. Rubber gloves to be worn and paste kneaded with the hands for 1 minute. Not more than 1000 gms., nor less than 500 gms. to be mixed at one time.
French.	Not stated.
German.	Mixed by hand for 1 minute then placed in Steinbruck-Schmelzer mortar mixer for 20 revolutions.

It will be seen that neither Britain nor France lays down any special notes. U.S.A. is rather better, chiefly owing to the addition of specified limits to the amount mixed at one time. The lower limit is so high that the small percentages of water usually accepted in English practice in cement testing, I do not think could be used.

The German method would seem to give the best chance of impersonal mixing. The type of mortar mill is illustrated in *Fig.* 8.

Suggestions have been made in England for designs of mixers (e.g. by Faija, *Figs.* 9 and 10), but have never been accepted for official specifications.

Amount of Water (Normal Consistency).

The various regulations are as follows :—

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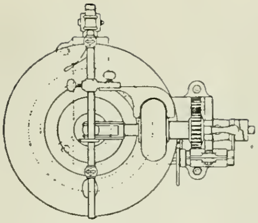
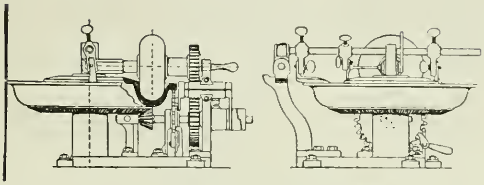
* See note on previous page regarding these two figures.



Plan.



Section. Elevation.

Fig. 8. Steinbruck-Schmelzer Mill.

TABLE II.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

Quantity of Water.

(Normal Consistency.)

British. (1) *Neat Cement*—not stated, except that "the mixture shall be plastic when filled into the moulds."

(2) *Mortar.*—"Sufficient water to wet the whole mass throughout without any excess being present."

U.S.A. Vicat needle apparatus with plunger 1 cm. in diam. Neat cement paste used—kneaded by hand—tossed 6 times from hand to hand held 6 in. apart and placed in rubber ring. Normal consistency when plunger after placing gently on surface penetrates 10 mm. in $\frac{1}{2}$ min. For *Mortar*, water to be used is taken from table below :—

% Water for Neat Cement.	% for mix 1–3 Ottawa Sand.	% Water for Neat Cement.	% for mix 1–3 Ottawa Sand.
15	9·0	23	10·3
16	9·2	24	10·5
17	9·3	25	10·7
18	9·5	26	10·8
19	9·7	27	11·0
20	9·8	28	11·2
21	10·0	29	11·3
22	10·2	30	11·5

French. For *neat cement* Vicat needle is used with plunger 1 cm. diam. A pat 4 cm. thick is used and consistency is correct when plunger penetrates to within 6 mm. of the bottom.

For *cement mortar* (1–3) for 1 kilo. of dry material amount of water = 55 gms. + $\frac{1}{5}$P where P = amount required for 1 kilo. neat cement, i.e., % for mix =

$$5{\cdot}5 + \frac{\%\text{ for neat cement}}{5}.$$

German. By Boehme's hammer test on a mortar cube. Correct amount of water when between the 90th and 110th blow liquid cement just begins to flow out of the notches of filling-box.

As will be seen the British specification is lacking in any precise statement. The writer considers this omission may be serious if the personal equation is to be eliminated.

The Americans and French have practically the same test, but the French limit gives a much wetter mix than the American, though both use more water than is usually considered right in England.

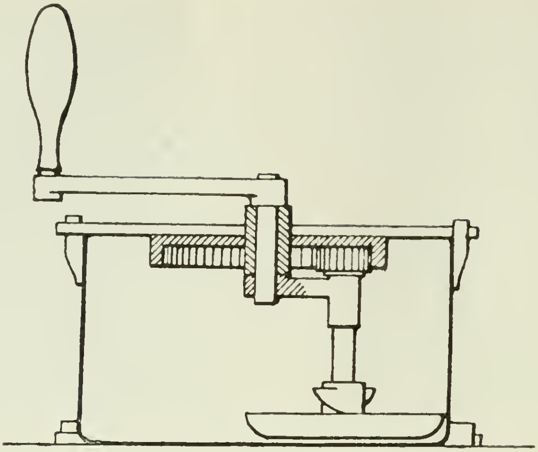


Fig. 9. Faija's Cement Gauger.

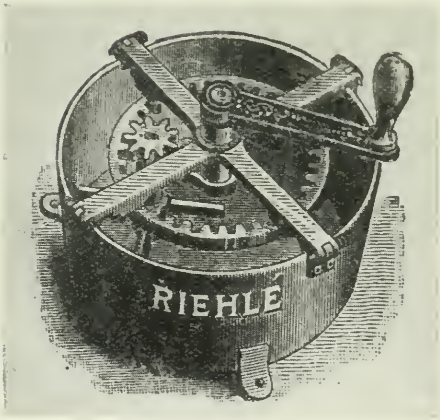


Fig. 10. Cement Gauger of Similar Construction to Faija's, but made by Messrs. Riehle.

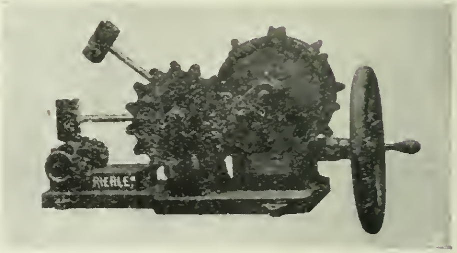


Fig. 11. Boehme Hammer, Riehle's Pattern.

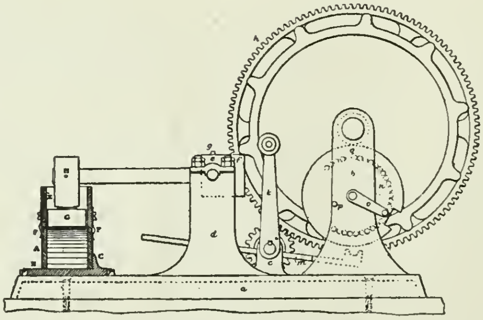


Fig. 12. Boehme Hammer as specified by Germany.

The German test for normal consistency takes advantage of the fact that after repeated blows on the mixture of cement, water can be forced up. The Boehme Hammer is shown in *Figs.* 11 and 12.

This test seems to the writer to be quite a sound one. It has been in use some years and is still retained. Those who use it regularly appear to approve of it very strongly. The only objection the writer has heard passed to this is that the anvil block, which is placed on top of the mortar to give a striking surface for the hammer, requires very careful placing to prevent jamming against the sides.

STRENGTH TESTS.

(*A.*) *Tensile Test—Neat Cement.*

The various regulations are as under :—

TABLE III.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

STRENGTH TESTS.

A. Tensile Test, Neat Cement.

British.	Standard briquette, no mechanical ramming or knocking, and only the hands to be used ; 24 hours in moist air. Then till 7 days old in water } 6 each ,, ,, 28 ,, ,, ,, ,, } Strength at 7 days at least 450 lbs. = P ,, ,, 28 ,, ,, ,, $P + \frac{40,000}{P}$ lb.
U.S.A.	None.
French.	Briquette (similar to British), 5 sq. cms. in cross section. Strength after 7 days at least 25 kilos. per cm^2 ≏ 356 lb./□″ ,, ,, 28 ,, ,, ,, 35 ,, ,, ,, ≏ 500 lb./□″ *No difference for sea work or not sea work.* Strength shall also increase at least 3 kilos/cm^2 (≏ 43 lbs./□″ between 7 and 28 days.) To be stored in sea water if for sea work.
German.	None.

(*B.*) *Tensile Test—Cement and Sand.*

The various regulations are as under :—

TABLE IV.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

STRENGTH TESTS (*contd.*).

B. Tensile Test, Cement and Sand.

British.	1 to 3 by weight. Leighton Buzzard sand to pass 20 × 20 and retained on 30 × 30. (Size of wire ·0164″ and ·0108″ respectively ; mesh. ·0336″ and ·0225″.) Moist atmosphere for 24 hours. In water till 7 days ; at least 200 lb./□″ = P ,, ,, ,, 28 ,, ,, ,, $P + \frac{10,000}{P}$ lb. Mortar to be placed in mould, heaped up twice and patted down with standard spatula.
U.S.A.	1 to 3 by weight. Standard Ottawa sand to pass 20 sieve and retained on 30. To be considered as remaining on 30 sieve when 5 grms. pass/min. when sifting 500 gms. Diam. of wires ·0165″ and ·011″. 24 hours in moist air and rest in water, at 7 days old at least 200 lb./□″ ,, 28 ,, ,, ,, ,, 300 lb./□″ The average at 28 days must be more than at 7 days.
French.	1 to 3 by weight. Standard Leucate shore sand supplied by administration. Equal quantities of the following materials are mixed :— (1) Grains passing 2 mm. (·079″) and retained on 1·5 mm. (·059″) (2) Grains passing 1·5 mm. (·059″) and retained on 1 mm. (·039″)

(3) Grains passing 1 mm. (·039″) and retained on ·5 mm. (·020″)
For sea work and not sea work.
At 7 days at least 8 kilos/cm² ≏ 114 lb./□″
At 28 ,, ,, ,, 15 ,, ,, ≏ 213 lb./□″
The strength must increase at least 2 kilos/cm² (28·6 lbs/□″) between 7 and 28 days.

German. None. (For hasty test on constructional work must show 12 kilos/cm² (172 lb./□″) at 7 days.)

As will be seen this latter test is used by all four countries, though in Germany it is not really a standard test and is only used as a rough works test.

As a note on these strength tests a consideration of fineness of grinding is now required.

The various specifications are as under :—

TABLE V.

SPECIFICATIONS FOR PORTLAND CEMENT.

FINENESS.

British (1920).
100 grams shaken for ¼ hour on each of the following, in order given :—
180 × 180 holes/□″ Mesh ·00376″ (Wire ·0018″)
76 × 76 ,, ,, Mesh ·00876″ (Wire ·0044″)
Residue on 1st not to exceed 14%
,, ,, 2nd ,, ,, ,, 1%

U.S.A (1917).
50 gms. shaken till not more than ·05 gm. passes per minute in the following sieve :—
No. 200, i.e. 200 × 200 holes/□″ mesh ·0029 (wire ·0021)
Residue not to exceed 22%.
(a variation of 1% allowed and reported as 22%)

French (1910).
100 gms. shaken on the following sieves :—
(1) 324 holes/cm² ≏ 2080/□″ ≏ 41 × 41
(2) 900 ,, ,, ≏ 5800/□″ ≏ 76 × 76
(3) 4900 ,, ,, ≏ 31500/□″ ≏ 178 × 178
Diam. of wires (1) ·2 mm ≏ ·00788″ mesh ·356 ≏ ·014″
(2) ·15 mm ≏ ·00592″ mesh ·1833 mm ≏ ·0072″
(3) ·05 mm ≏ ·00197″ mesh ·0929 mm ≏ ·00365″
(*a*) *For sea work.* Residue on 900 not to exceed 10%
(*b*) *Not for sea work.* ,, ,, 4900 ,, ,, ,, 30%
,, ,, 900 ,, ,, ,, 10%

German (1909–1920).
100 gms. shaken—no time given. Sieve 900 holes/cm² ≏ 76 × 76.
Mesh = ·222 mm. ≏ ·00875″ (limits = ·215–·240 mm.).
Residue not to exceed 5%.

The effect of fineness of grinding on the strength as given by the two strength tests (*A*) and (*B*) is shown in Table VI. :—

TABLE VI.

FINENESS.
Professor R. K. Meade.

Showing increase in sand strength due to fine grinding.
Tensile strength in pounds per sq. inch.

NEAT.

	1 day.	7 days.	28 days.	3 mnths.	6 mnths.	1 year.	2 years.
As received	327	630	725	720	760	825	850
Ground to pass a 200 mesh sieve	210	525	540	540	560	575	560

1 : 3 MORTAR.

	1 day.	7 days.	28 days.	3 mnths.	6 mnths.	1 year.	2 years.
As received	—	278	357	387	390	410	425
Ground to pass a 200 mesh sieve	—	480	555	575	615	623	640

It would seem to be extremely doubtful if the test of neat cement is really valuable as a measure of the quality of a cement. As is shown in Table VI. the finer a cement is ground the lower the strength given by this test, but the higher the value given by cement and sand test.

If this is the case there does not appear to be much reason for specifying this test.

The writer considers the cement and sand test the most important of the strength tests in use. It obviously is some measure of the power the cement possesses of sticking together particles of stone—which property is the one most desired in a cement.

No special machine is specified for the actual breaking of the briquettes. The rate of loading is specified and in the British specification the shape of the grips of the machine also. The grips should be greased.

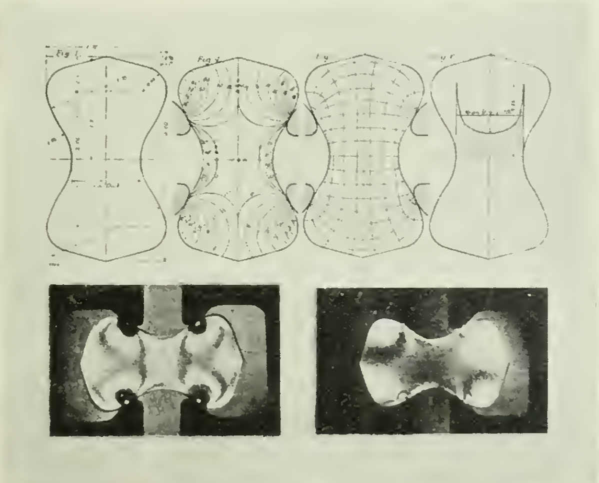


Fig. 13. Professor Coker's Diagrams of Stress. Distribution in Celluloid Models of Cement Briquettes.

It may be interesting to consider an experiment of Prof. L. G. Coker, F.R.S., on the influence of the form of briquette on the stresses produced.

By making models of the briquette in celluloid or some like transparent substance and examining by polarised light when under load, it is possible (by methods brought to a high state of perfection by Prof. Coker) to obtain a measure of the stress distribution present.

This distribution is shown in *Fig.* 13.*

It will be seen that the maximum stress is something of the order of 1·75 × mean stress.

He experimented with the various forms used in the different specifications and found a variation in this constant from 1·7 to 1·95.

Thus although the absolute value of these constants may not be applicable to such a material as cement since they were determined for celluloid, etc., still it is reasonable to suppose that they indicate the order of magnitude of the stresses and that they certainly show that the strengths of varying shapes of briquettes cannot be compared with each other directly.

(*To be concluded.*)

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* From *Engineering*, 1912, p. 825.

One-Way System of Formwork.

THE AMERICAN "FLAT SLAB" TYPE OF BUILDING: ITS ADVANTAGES AND DESIGN.

By A. E. WYNN, B.Sc., Assoc. M. Am. Soc. C.E.

(Continued from page 102 of our February issue.)

Distribution of Steel to resist Moments.—To resist the negative moment over the support in each strip *A* take the sum of the areas of steel in one cross band and one diagonal band. To resist the positive moment in each strip *A* take area of steel in one cross band. To resist the negative moment in strip *B* take the steel included in width of strip *B*. To resist the positive moment in strip *B* take area of steel in one diagonal band.

Compression in concrete as before.

Example:—

Interior panel 20 ft. × 20 ft. $L=20$ ft.

Loads and stresses as before. Thickness of slab, sizes of cap and depressed panel will be same as in previous example.

Strip *A*. $+M=WL/80=\frac{128,000\times 20}{80}=32,000$ ft.-lb.

Effective depth $8\frac{1}{4}-1=7\frac{1}{4}$ in.

Area of steel in band $=\frac{32,000\times 12}{16,000\times \cdot 874\times 7\cdot 25}=3\cdot 79$ sq. in., say 19 $\frac{1}{2}$ in. ro. bars.

Strip *B*. $+M=WL/120=\frac{128,000\times 20}{120}=21,340$ ft.-lb.

Effective depth $8\frac{1}{4}-1\frac{1}{4}=7$ in.

Area of steel $\frac{21,340\times 12}{16,000\times \cdot 874\times 7}=2\cdot 62$ sq. in., say 14 $\frac{1}{2}$ in. ro. bars.

$-M=WL/120$. Effective depth $=7\frac{1}{2}$ in.

Area of steel $=2\cdot 53$, say 13 $\frac{1}{2}$ in. ro. bars.

Strip *A*.—Depth of depressed panel is found as before $=12$ in.

$-M=WL/30=\frac{128,000\times 20}{30}=85,400$ ft.-lb.

Effective depth $12-1\frac{3}{4}=10\frac{1}{4}$ in.

Area of steel $\frac{85,400\times 12}{16,000\times \cdot 868\times 10\cdot 25}=7\cdot 21$ sq. in. say 37 $\frac{1}{2}$ in. ro. bars.

It is common practice to carry all the bars over two bays, in order to save steel and splicing them so that half the bars are spliced over each column. The bars in the rectangular bands are carried to the quarter point, or in this case 5 ft. beyond the column, and the bars in the diagonal bands are lapped 2 ft. or sufficient to develop bond.

If we adopt this method the steel to resist the negative moment in strip *A* will be one diagonal band or fourteen bars plus one rectangular band or nineteen bars plus one half a rectangular band from the bars that extend to the quarter point, or nine bars, making in all forty-two bars, which is more than sufficient, as we have found we require thirty-seven bars. In this method all of the bars are bent up into the top of the slab at the column.

If we carry all the bars only over one panel then we should have fourteen bars from the diagonal band, leaving twenty-three to be provided from the rectangular band, and we should bend up twelve bars from each side of the column, carrying them to the quarter point and leaving seven bars straight in the bottom of the slab. The widths of the bands will be $\cdot4L$ or 8 ft.

Comparing the two designs we see that the first requires 3·7 lb. of steel, and the second 3·45 lb. of steel per sq. ft.

In the above examples we have taken the width of the depressed panel as $L/3$ or 6 ft. 8 in. This is the minimum width allowable; however we could have made it greater if desired. Instead of assuming the width and finding the necessary depth, we could have assumed a depth and found the corresponding width to give the required amount of compression.

Supposing in the last example we had wished to use a drop of 3 in., giving a total depth $t'=11\frac{1}{4}$ in. and effective depth of $11\frac{1}{4}-1\frac{3}{4}=9\frac{1}{2}$ in. Then required width of $\text{D.P.}=\frac{85{,}400}{350\times\cdot396\times\cdot868\times9\cdot5^2}=7\cdot86$, say 8 ft. This depth would require 40 $\frac{1}{2}$ ro. bars for negative moment.

It is usual in four-way design to bend up all the bars over the columns and, according to the amount of steel thus available, to proportion the size of the depressed panel.

It is not advisable to make the drop less than 2 in.

We will now consider the design of a slab without a depressed panel. The following two rules are taken from the Chicago Building Code.

(1) The sum total of the positive and negative bending moments, regardless of sign, shall be equal to that computed by the formula :—
$\text{B.M.}=WL/8(1\cdot53-4k+4\cdot18k^3)$, where "$k$" is the ratio of radius of the column cap to L.

(2) This B.M. is to be divided between positive and negative moments in same proportion as in typical square panels for two-way or four-way systems as given above for interior and wall panels respectively. Compression in the concrete : Width of beams shall be width of steel bands, and where not sufficient use compression steel in the bottom of the slab.

Example :—

Panel 20 ft. × 20 ft. $L=20$. Two-way design.
Live load $=200$ lb. per sq. ft.
Finish $=20$,, ,,
Assume a 10 in. slab $=120$ lb.
$w=120+200+20=340$.
$W=340\times400=136{,}000$ lb.

$$k=\frac{4\cdot5/2}{20}=\cdot1125.$$

$$\begin{aligned}\text{Total B.M.}&=136{,}000\times20/8(1\cdot53-4k+4\cdot18k^3).\\&=340{,}000(1\cdot53-4\times\cdot1125+4\cdot18\times\cdot1125^3).\\&=365{,}000\text{ ft. lb.}=WL/7\cdot45.\end{aligned}$$

In the previous example the total B.M. was $WL/(1/30+1/60+1/120+1/120)2=WL/7\cdot5$.

$-M$ in A band $= \cdot 5$ of total moment.
$+M$,, ,, ,, $= \cdot 25$,, ,,
$-M$,, B ,, $= \cdot 125$,, ,,
$+M$,, ,, ,, $= \cdot 125$,, ,,

Dividing the new moment in the same proportion we get—

$-M$ in band $A = \cdot 5 \times 365{,}000 = 182{,}500$ ft.-lb. for two bands.
$+M$,, ,, ,, $= \cdot 25 \times 365{,}000 = 91{,}250$,, ,, ,, ,,
$-M$,, ,, $B = \cdot 125 \times 365{,}000 = 45{,}625$,, ,, ,, ,,
$+M$,, ,, ,, $= \cdot 125 \times 365{,}000 = 45{,}625$,, ,, ,, ,,

Either shear around the cap or compression at the column will govern the thickness of the slab.

$$\text{Shear} = \frac{136{,}000 - 3\cdot 14(4\cdot 5^2/4) \times 340}{3\cdot 14 \times 4\cdot 5 \times 12 \times 875} = 84 \text{ lb. per sq. in.}$$

which is less than the allowable compression at the column $= \dfrac{182{,}500/2 \times 12}{\cdot 868 \times 8\cdot 75} = 144{,}000.$

$$\text{Stress in the concrete} = \frac{144{,}000}{12 \times 10 \times \cdot 396 \times 8\cdot 75} \times 2 = 693 \text{ lb. sq. in.,}$$

so that the assumed thickness of slab was correct. The amount of reinforcing is found as before.

By using some of the straight steel in the bottom of the A bands as compression steel over the column, it would be possible to cut down the thickness of the slab slightly, or special compression steel can be used, but it would not be economical in most cases.

The next point to consider is the design of a rectangular panel.

Where the length does not exceed the width by more than 5 per cent. the design is the same as for a square panel, taking L as the mean of the two sides. When the length exceeds the breadth by more than 5 per cent. the following rules are to be observed.

Four-Way System :—

(1) Amount of steel in strip A long direction, both positive and negative, shall be same as required for same strip in square panel whose side equals long side of rectangular panel.

(2) Amount of steel in strip A short direction, both positive and negative, same as for square panel whose side equals the short side of the rectangle.

(3) Amount of steel in strip B, positive and negative, shall be same as required for similar strip in square panel of side equal to the mean of short and long sides of the rectangle.

(4) Steel in the short side should not be less than two-thirds the steel in the long side. The long side should not exceed the short side by more than one-third.

Two-Way System :—

(1) Amount of steel for both positive and negative moments in strip A shall be determined in the same manner as for the four-way above.

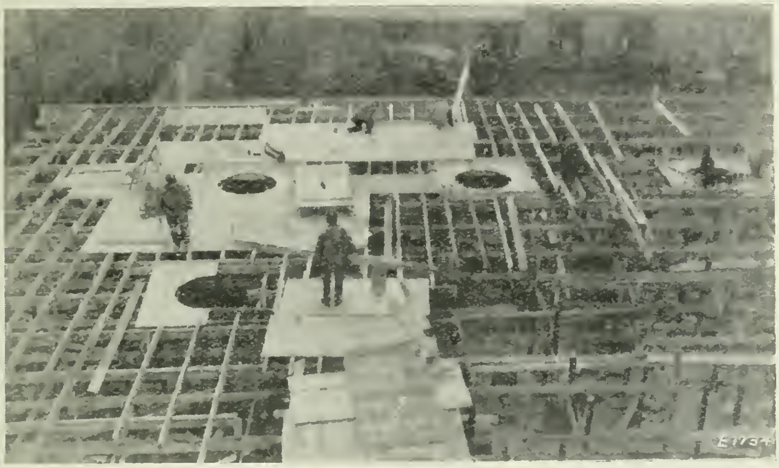
(2) Amount of steel in strip B, both positive and negative, running in short direction, shall be equal to that required for same strip in square panel whose side equals long side of the rectangle.

(3) Amount of steel in strip B, both positive and negative, running in long direction, shall be equal to that required for same strip in square panel whose side equals short side of the rectangle.

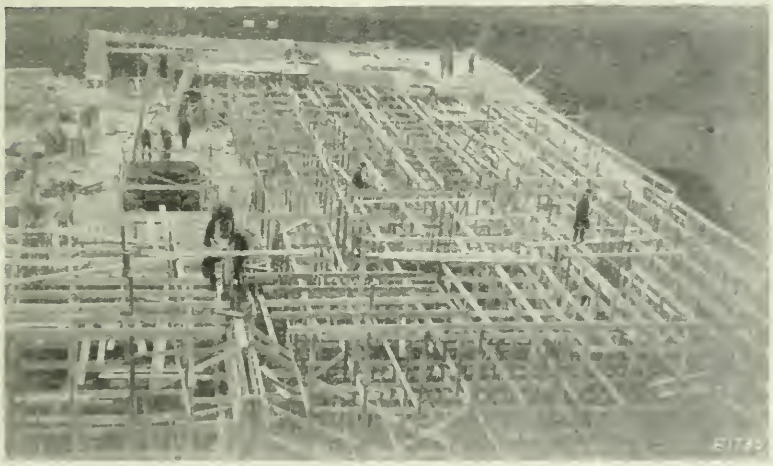
(4) Steel in strip B long direction should be not less than two-thirds that in the short direction. The long side should not exceed the short side by more than one-third.

If these rules are followed there will be no difficulty in designing rectangular panels.

Roof slabs are designed in exactly the same way as floor slabs, only the live load is very small, and deflection rather than strength controls the design. It is customary not to make the slab thickness less than 6 in., though for small panels, say 15 or 16 ft. square, 5 in. will be found satisfactory.



Two-Way System of Formwork.
Note made-up Deck Panels in foreground.



The Two-Way System of Formwork.

If the roof is designed for the actual live and dead loads too small a percentage of steel will be obtained to resist the stresses due to temperature changes and the slab may crack. It is therefore usual practice not to design a roof slab for less than 90 lb. per sq. ft.; this can be taken to include the snow load, roof finish and fill if any. The slab itself can be pitched to the necessary slope to avoid using cinder fill.

All the above rules for design apply only to a building that is at least three bays wide and that is of frame construction, that is the slabs are poured monolithic with the columns.

Buildings are designed that are only two bays wide, usually 25 or 30 ft. bays, but they are unusual, not economical and require special treatment, so they will not be discussed here.

As it is necessary that the wall columns be capable of taking some tension it is not recommended that flat slab floors be used in conjunction with exterior bearing walls, either old or new. If, however, it is necessary to use an exterior bearing wall the following rule from the Chicago Building Code should be followed :—Lay up in cement mortar and stiffen with pilasters as follows: for 16 in. walls 4 in. pilasters, for 12 in. walls 8 in. pilasters. Width of pilaster to be not less than the diameter of the column nor less than one-eighth the distance between pilasters. They are to be located as far as possible opposite to the columns and be corbelled out 4 in. at the top, starting at a level of base of cap.

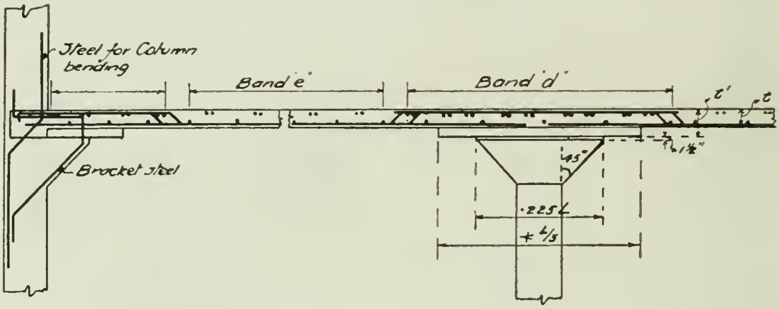


FIG. 6

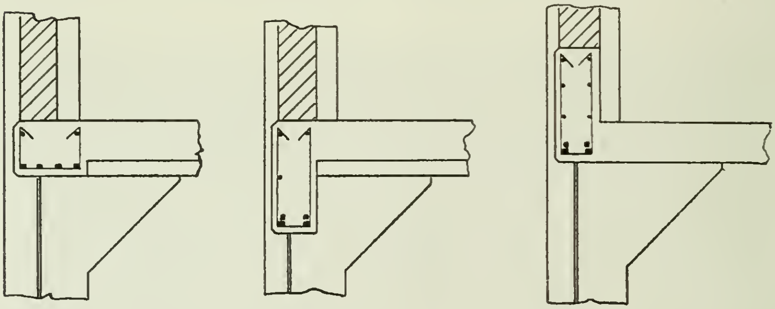


FIG 7 FIG 8 FIG 9

TYPES OF WALL BEAMS

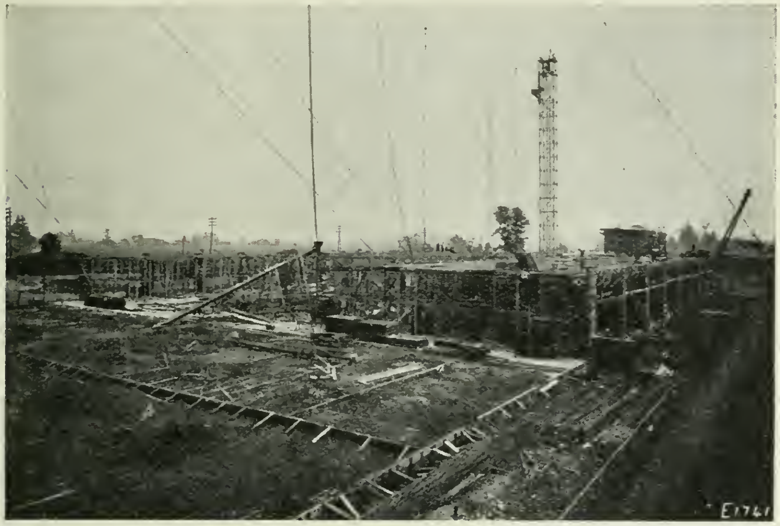
Not less than 8 in. bearing is to be provided the full length of the wall. Coefficients of bending moment are to be the same as for interior panels, but increase the positive moments in strips *A* and *B* 50 per cent. between wall and first line of columns.

Having dealt with all the points in the design of the slabs themselves, it is now necessary to consider the design of the columns, wall beams, and the provision for carrying concentrated loads.

The interior columns are not usually designed for eccentric loading, but their diameter should not be less than one-twelfth the clear height nor less than one-twelfth the panel length; this rule will cover all ordinary cases of eccentric loading.

Wall columns are constructed with brackets and depressed panels (see *Fig.* 6). The depressed panels are similar to those in the interior bays only they are half the width.

The brackets are usually made the full width of the columns and the depth is governed by the allowable shear on the depth of the bracket and on the slab along the perimeter of the bracket. It is good practice to reinforce the bracket to obtain a good bond to the column, tying the bars back to the column steel ; a proportion of the vertical shear can be taken by these bars.



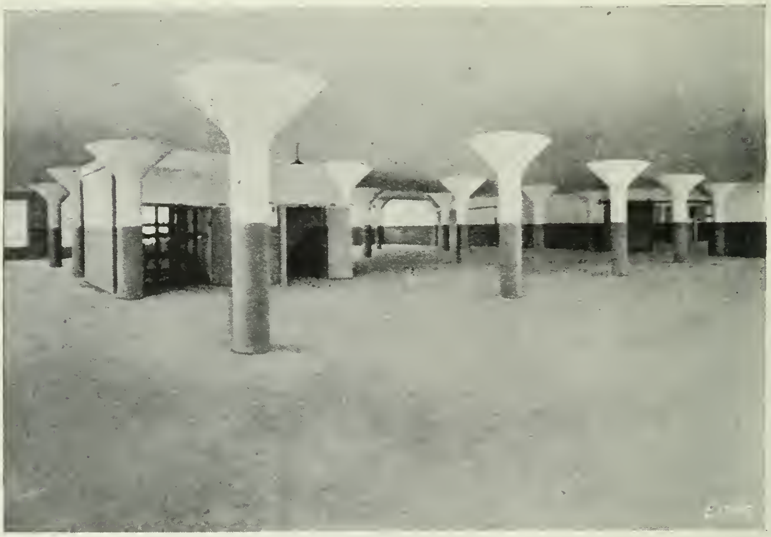
NEW BUILDING FOR HAYNES AUTOMOBILE COMPANY, KOKOMO, IND.—TYPICAL FOUR-WAY SYSTEM.
Note Spouting System.

INTERIOR VIEW OF A MACHINE SHOP—WITHOUT DEPRESSED PANEL.

The wall columns have to resist a bending moment as well as the vertical load, and are therefore designed for bending and direct compression.

It is usual to assume a B.M. of $WL/60$ at the floors and $WL/30$ at the roof. The

Department Store—Ornamental Column Cap and Depressed Panel.



Interior View of Warehouse—No Depressed Panel.

columns both above and below the slab are designed for this moment. Short bars are used, bent so that they are on the tension face of the column both above and below the slab (see *Fig.* 6). They should extend to a point one-third the distance from the floor line to the base of the cap and the amount of steel required for the above moments should be independent of that required to carry the vertical load. At the roof they are bent over into the slab.

Wall beams are designed in three principal ways: (1) a deep narrow beam; (2) a shallow wide beam the depth of the depressed panel, this allows for better lighting and is the best method; (3) when still more light is required the wall beams are placed above the slab (see *Figs.* 7, 8, 9).

There is always a half band of steel adjacent to the wall beams, and as this has a smaller effective depth than the steel in the beam, part of it cannot be fully stressed until the steel in the beam is overstressed, consequently the beam must be designed to carry some proportion of the slab load. The beams are also under torsional stress due to the deflection of the slab and therefore should not be made too narrow.

There are various opinions as to what proportion of the slab load should be borne by the wall beams. It varies, according to different regulations, from one-fifth to one-twelfth of a panel load uniformly distributed along the beam.

The Chicago Code specifies one-fifth of a panel load to be carried by the wall beams, but this seems to be excessive. Probably one-eighth is the best value to use, although the writer uses one-twelfth with successful results. In addition, of course, there is the dead load of the beam and wall to be allowed for.

All corner beams should be designed for one-quarter of a panel load as they receive a greater proportion of the slab load.

The wide shallow beam, the same depth as the depressed panel, is best suited to resist the torsional stresses and gives the maximum stiffness to the structure.

Where the beam is carried above the slab it is important to use plenty of stirrups to tie the slab to the beam, also as there is a possibility of cracking between the slab and the beam it is well to provide sufficient reinforcing in the bottom of the beam above the slab to carry the dead load of beam and wall.

All outside surfaces of wall beams should be reinforced to resist temperature stresses.

When the beam is carried up to the window sill the whole depth may be utilised, although it is good practice not to use less than four bars in the beam.

Concentrated loads on the slab are best carried by beams which are always used to frame around stairs, elevator openings and to carry heavy walls (see *Fig.* 1A).

Whenever possible the stairs and elevator shaft are placed in one panel, preferably in the corner of the building or outside the building altogether. This avoids cutting up the slab with beams and gives a clear working space.

In addition to the concentrated loads all beams occurring on the centre line of the columns should be designed to carry one-quarter of a panel load uniformly distributed. These interior beams may be made wide and shallow, the depth of the depressed panel, or narrow and deep.

When the four-way system is used it is advisable to put a few bars in the bottom of the slab diagonally across the corner panel to tie in the beams. If the concentrated loads are light, such as tile partitions, they may be safely carried on the slab itself as the load is distributed over a considerable width.

Tests on flat slab buildings have been very numerous and they all show that the ordinary method of design is conservative. Deflection rather than stress controls the design of flat slabs and slabs designed by the Chicago Code should not deflect more than 1/800 of the span, tests show that most of them do not deflect much more than half this under a load equal to twice the load for which the slab is designed.

The writer's firm recently tested a floor slab designed by a much less conservative method than called for by the Chicago Code and the deflection at the centre of the slab, under a live load of 1¾ times the designed load, was 1/1300 of the span.

The stress in the steel obtained from extensometer readings are always very much less than the calculated stress. When tested to destruction the slab yields very slowly, showing that danger of collapse from sudden overloading is very remote.

A few practical points in the construction of flat slab buildings will now be mentioned.

As in any type of reinforced concrete structure it is important that the steel bars be held rigidly in position to prevent displacement. This is done by using spacer bars of various makes; these are slotted to receive the bars according to their spacing, using about three bars to a band. Spacer bars are not necessary if the bars are carefully wired together at their intersections, but they facilitate placing and ensure correct spacing. The top steel is supported by either concrete blocks about 6 in. square or by special steel chairs made for the purpose, about three on each side of the depressed panel being required.

Columns should be poured up to the bottom of the cap or bracket and allowed to settle about 12 hours before pouring the slab, otherwise there may occur a crack at this point.

Construction joints should be vertical and through the centre of the bay midway between columns.

Formwork for flat slab buildings is very simple. The interior columns and caps are usually round and steel forms are always used. The wall columns are rectangular and it is economical to keep the same section throughout as far as possible.

One floor of slab forms is used for buildings up to six storeys, above that height two sets will be more economical.

There are two general methods of building flat slab forms. The first may be called the one way method. In this the deck consists of " one by sixes " cleated together to form panels of convenient size to handle. The deck is carried on " three by six " joists about 14 ft. long and about 30 in. on centre. The joists are carried on " four by four " posts about 7 ft. apart and resting on wedges to facilitate stripping (see illustration at top of this article.)

In the second or two way method the deck is made as before and is carried on " two by sixes " spaced 24 to 30 in. on centre. These in turn are carried by " four by six " girts about 5 ft. on centre. The girts are carried on " four by four " posts about 5 ft. on centre.

Of course the lumber sizes and spacing depend on the thickness of slab to be carried.

After stripping about four posts to a panel are left in, these usually bear directly on a loose board in the deck so that the stripping can take place without disturbing them.

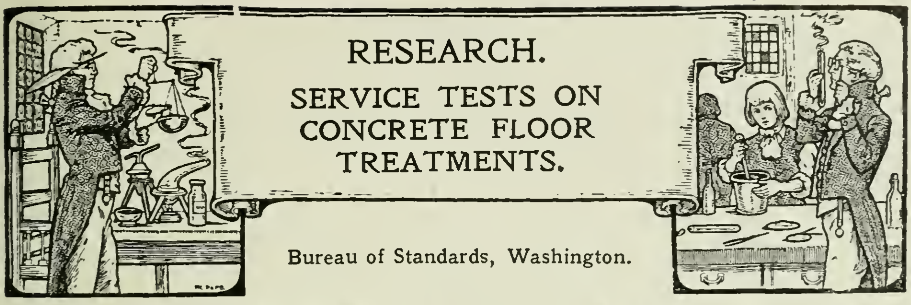
MEMORANDUM.

Concrete Mattress Blocks.—The following particulars are abstracted from an article in the *Engineering News-Record* :—

Flexible concrete mattress construction by stringing pre-cast concrete blocks on steel cable, as beads are strung on a thread, is the method adopted in improving the channel of the Miami River at Dayton, Ohio. The area of mattress formed by 500 blocks is 1,000 sq. ft., each block being 24 by 12 by 5 in. and weighing about 118 lb.

The blocks were moulded and stored in a central yard. Block distribution by wagons, with a special body, was found to be most economical owing to the scattered locations of the placing operations, the steep descents from the levee tops to the beach and the rough and soft roads. The blocks are distributed along the work in the numbers required, so as to keep short the distance they must be carried in placing; in practice this distance averages perhaps 20 ft.

Wire rope on reels is hauled to a point on the levee top, central to the operation in progress. The rope, after being straightened, is cut into lengths twice the width of the mattress and enough longer to provide a loop for anchorage to the toe wall and " pig tails " at the free ends for anchorage to the edging blocks. The cut ends of the rope are threaded through holes in the blocks.



RESEARCH.

SERVICE TESTS ON CONCRETE FLOOR TREATMENTS.

Bureau of Standards, Washington.

Some interesting tests were recently undertaken by the Bureau of Standards, Washington, D.C., on concrete floor treatments, and we publish below a short abstract from the Report on these tests. In describing the tests, it is stated in the report that the materials used were applied to slabs in the corridors of the Bureau of Standards Building, where some of the floors began to dust and crumble. We would here remark that a concrete floor properly made, and with the right aggregates should not need any treatment for dusting. But apart from this, the experiments made are useful in showing what has proved successful in overcoming the trouble, should it arise.—Ed.

PURPOSE OF TESTS.

Numerous inquiries for information concerning the relative merits of various concrete floor treatments have led to a comparative study of several proprietary treatments and a few " home treatments." The investigation has been based mainly upon observations of treated concrete floor panels under actual service conditions, and, therefore, the results are not quantitative or necessarily conclusive, but are in general indicative of what may be expected of the various treatments when exposed to such conditions for the stated periods of use. Pending the development of a suitable apparatus for making quantitative wear tests, it is believed that the knowledge gained from this study will be of considerable value since it shows the behaviour of the treatments placed side by side under as nearly the same traffic conditions as could be obtained for a test of this kind.

DESCRIPTION OF TESTS.

The materials were applied to the slabs in the corridors of the North-west Building of the Bureau of Standards, which is used for laboratory purposes and was completed in March, 1918. The building was occupied shortly after this time and very soon the floors began to dust and crumble at the surface. Hence, it may be said that these floors offered an excellent opportunity for determining the merits of such treatments. The first materials were applied about five months after the floors were completed and other treatments were applied during the following six months.

The sections of the floor which are referred to as panels are eight feet square, i.e., they extend the width of the corridor and eight feet along its length. The traffic on the different panels is similar, but since the entrance is at the centre, it is evident that the panels near the entrance are subjected to more use than those near the ends. With the exception of the fact that laboratory machines and office fixtures are occasionally moved over the floors, the panels are subjected only to light foot traffic.

The effect of the traffic was studied in comparison with panels which were left untreated. The determination of the wear is based on careful observations. The relative hardness was measured roughly by the resistance of the surface to scratching with a steel-pointed tool.

MATERIALS.

The materials included in these tests comprised seventeen proprietary materials, which were in most cases submitted by the manufacturers, and the home treatments were prepared in the laboratory according to formulæ which have been recommended. These latter were :—Sodium Silicate ; Aluminium Sulphate ; Linseed Oil ; Fuel Oil and Soap ; and Soap Treatment.

In order to avoid difficulties arising from the direct reference by trade names the materials and tests are described under reference letters.

RESULTS OF TESTS.

Treatments A to D consisted of a solution of magnesium fluosilicate of varying strengths between 8·7 per cent. up to 15 per cent., and gave varying results, some of which were satisfactory, according to the strength of the solution employed and the method in which it was applied.

Treatments E and F.—Here again magnesium fluosilicate was used, but with an admixture of zinc fluosilicate in one instance and magnesium sulphate and free hydrofluosilic acid in the second case. The results were not satisfactory.

Treatment G.—This was a 16 per cent. solution of zinc sulphate with about 4·5 per cent. free sulphuric acid. It was applied without dilution in two coats. After the first treatment had dried for four hours, the surface was scrubbed with hot water and mopped dry, when the second was applied.

This panel has been in service two years and three months. The surface is very hard and uniform. No signs of wear are apparent. The treatment gives a darker appearance than the original concrete.

Treatments H and I consisted of solutions of sodium silicate, with, in one case, small addition of organic acid.

After two years and two months the surface was in both instances hard and uniform, showing no signs of wear.

Treatment J.—A 15 per cent. solution of aluminium sulphate applied in three coats which were dilutions of the original solution as follows: 1st, one part solution to two parts water; 2nd, one part water to one part solution; 3rd, two parts solution to one part water. The treatment was applied liberally with a whitewash brush at intervals of 24 hours.

This treatment was applied to several panels in the corridor and to the floor of one large laboratory room, where it was necessary to keep the dust down on account of the machinery. The treatment has been in use one year and six months and has proved quite satisfactory. The surface is not quite so hard as was obtained by some of the other treatments, but it has been effective in holding the dust. This is a very economical home treatment which can be easily applied without interfering with the traffic.

Treatments K and L.—The first of these was a grey paint consisting of a pigment of basic lead sulphate, siliceous matter and carbon in a tung oil rosin varnish vehicle (mineral spirits thinner), and the second was a china wood oil varnish. Neither of these treatments can be said to be very satisfactory. In the case of **Treatment M,** however, where china wood oil varnish was also used, the surface to which it was applied showed no appreciable signs of wear after two years and two months.

Treatment N.—The material consisted of a thin-bodied mineral spirits varnish applied in two coats at an interval of 24 hours and kept covered with a bridge of plank until dry.

The panel has been in service two years and one month. The coating seems to be worn through where most used, as shown by the lighter colour at these places. This panel was originally weak and crumbling badly, and hence the test was quite severe.

Treatment O.—This was a grey paint with a pigment of basic lead sulphate, zinc oxide, barium sulphate, siliceous matter, and carbon in a linseed oil, rosin (and probably some tung oil) vehicle, having a mineral spirits thinner.

This panel has been in service one year and five months, and shows no signs of wear except a few scratches which were probably caused by moving machinery over it. The treatment gives a wax-like surface, which is not especially resistant to scratching but seems to be reasonably durable under foot traffic.

Treatment P.—This was a very thick paint consisting of a pigment of zinc oxide, lithophone and bone black in a varnish vehicle containing rosin. It was applied in one coat after the floor had been thoroughly swept.

This treatment has been in service one year and six months. It shows several large scratches due to moving machinery over it and a few small spots have blistered and worn away. The thick film obtained with this material is very pleasing to walk upon but has not proved durable under the conditions to which it has been subjected. It is believed that a preliminary roughening of the concrete would avoid blistering and give a coat that would be satisfactory for office purposes.

Treatment Q.—This treatment consisted of a solution of heavy hydro-carbon wax in a light hydro-carbon oil applied to the surface in two coats 24 hours apart.

The panel has been in service two years and three months and shows considerable wear. The object of this treatment is only to hold the dust, and no claims are made as to hardening the surface.

Treatment R.—This consisted of a mixture of waxes applied to the floor in a molten condition. The object of this treatment is similar to that of Material Q. More wax is left on the surface, which acts as a binder to loose particles. One panel and one office room were treated with this material. Both show considerable wear. This has been in service two years and four months.

Treatment S.—This treatment consisted mainly of linseed oil with a small addition of citronella. It was applied in one coat and kept covered until dry.

While this panel has not proved entirely satisfactory, it appears to be harder at this time than it was one year ago. The panel probably should have had two applications instead of one. The directions advised one coat for new floors and two coats for old, badly worn floors. The appearance obtained was not uniform, which indicates that the proper amount of the treatment was not applied, and hence it is believed that little weight should be given the test.

Treatment T.—This consisted of four applications of raw linseed oil thinned with turpentine.

It has been in service two years and two months. The results obtained at first were not satisfactory but the surface appeared to harden gradually until at present it is quite hard. It appears to be resisting the wear very well.

Treatment U.—This treatment and the one following are what might be called janitor processes. It has been noticed that concrete floors under actual use sometimes take on a polish or present a wax-like appearance. In order to determine if this condition was due to the precipitation of soap in the concrete, some sections of the floor were frequently scrubbed with a thick soap solution. The polished condition did not occur in this case, which was believed to be due to the fact that the floor was very porous and hence the solid matter from the treatment was not retained in the concrete.

Treatment V.—This was an emulsion of fuel oil and soap in the proportion of three quarts of oil, two bars of ivory soap and four gallons of water. This treatment was not included in the series described above, but was applied recently in the corridors of another building, the floors of which were originally much better than those described. The emulsion was applied with a mop at intervals of a week or two. About ten applications were made and the floors were greatly improved. They do not appear to be dusting and the surface is somewhat harder than the original. This application leaves the floor slippery for a few hours.

CONCLUSIONS.

1. The above-described experience with materials of the magnesium fluosilicate class indicates that very good results may be obtained by such treatments, but that there is a need for more knowledge concerning the proper strength of solution and method of application.

2. The zinc sulphate treatment has given excellent results.

3. The surface coating materials are most effective in entirely eliminating the dust. The length of service that can be obtained from this type will usually be limited to a year or two, depending on the nature of the traffic, but since the greater portion of the floor does not usually receive a large amount of wear, the worn places may be resurfaced at a small expense.

4. Two home treatments, viz., I and J, have proven very successful and are quite inexpensive to apply. The following instructions are given for the use of the home treatments :—

A. *Sodium Silicate Treatment.*

Commercial sodium silicate usually varies in strength from 30 to 40 per cent. solution. It is quite viscous and has to be thinned with water before it will penetrate the floor. In ordinary cases it will be found satisfactory to dilute each gallon of the silicate with four gallons of water. The resulting five gallons may be expected to cover 1,000 sq. ft. of floor surface, one coat. However, the porosity of floors varies greatly, and the above statement is given as an approximate value for estimating purposes.

The floor surface should be prepared for the treatment by cleaning free from grease, spots, plaster, etc., and then thoroughly scrubbed with clear water. To get the best penetration the floor should be thoroughly dry, especially before the first application, and, if practical, it is well to let it dry for several days after the first scrubbing. The solution should be made up immediately before using. It may be applied with a mop or hair broom and should be continuously brushed over the surface for several minutes to obtain an even penetration. An interval of 24 hours should be allowed for the treatment to harden, after which the surface is scrubbed with clear water and allowed to dry for the second application. Three applications made in this manner will usually suffice, but if the floor does not appear to be saturated by the third application, a fourth should be applied.

This treatment when properly applied gives a very hard surface that is bright and uniform in appearance. The commercial sodium silicate can be obtained from wholesale druggists at a cost of 40 c. or less per gallon.

B. *Aluminum Sulphate Treatment.*

The solution of aluminium sulphate for this treatment should be made in a wooden barrel or stoneware vessel. The amount required may be estimated on the basis of one gallon of solution for each 100 sq. ft. of area. For each gallon of water 2½ lb. of the powdered sulphate will be required. The water should be acidulated with commercial sulphuric acid by adding 2 c.c. of the acid for each gallon. The sulphate does not dissolve readily and has to be stirred occasionally for a period of a few days, until the solution is complete.

The floor should be cleaned of grease spots, plaster, etc., then thoroughly scrubbed. When the surface is entirely dry, a portion of the sulphate solution may be diluted with twice its volume of water and applied with a mop or hair broom. After 24 hours dilute a portion of the original solution with an equal volume of water and apply in the same manner as the first. Allow another interval of 24 hours and make an application, using two parts of the sulphate solution to one part of water. Each application should be continually brushed over the surface for several minutes to secure a uniform penetration. After the third application has dried, the surface should be scrubbed with hot water.

This treatment will give good results at a cost about equal to that of the sodium silicate treatment.

MEMORANDA.

Water Gauge for Concrete.—In view of the importance of accurately gauging the water content in batches of concrete, a device which is shortly to be put on the market by the Austin Machinery Corporation, of Chicago, will be of considerable interest to engineers in this country. This device, the total weight of which is about 200 lb., takes the form of a water meter specially adapted for use with concrete mixers. The pump is operated from the shaft of the mixer, and the meter operates automatically. By setting a pin on the meter any pre-determined amount of water is supplied to each batch of concrete, the supply being controlled by a two-way which is actuated by the starting lever of the mixer. It is stated that the device has been extensively tested, with satisfactory results.

Shearing Stresses in Rectangular Reinforced Concrete Beams.—In the concluding part of this article which appeared in our February number, page 85, the following correction should be made: sixth line from the bottom of the page; after X_oX, the last part of the sentence should read:

ac itself having the inclination ϕ with the horizon.

CONCRETE IN THEORY — AND PRACTICE. —

A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.

REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED.

CHAPTER V.—*continued.*

Design of Columns.

70. The calculation for the column in Section 69 was for a top tier column, that is, one which stopped at the beam it supported.

Such a column is subjected to greater bending stresses than a column of a lower tier which runs up above the beam it carries, because in that case the bending moment from the beam is carried partly by the upper length of column and partly by the lower.

Suppose, as an example, we now calculate the stresses in a standard outside column 16 in. × 16 in., supporting a standard T beam 20 in. × 8 in. 25 ft. span, carrying 25,000 lb. distributed load at roof level, and also supporting a similar beam and load at third floor 12 ft. 6 in. lower, a second floor beam 12 ft. 6 in. lower still, and so on. Now the stresses in the upper tier are exactly as calculated in Section 69. Those in the lower tier under third floor will now be calculated.

Column carries 12,500 from roof level.
,, ,, 12,500 ,, floor level.

25,000 total.

Equivalent area of standard 16 in. × 16 in. column = 300 sq. in.

Therefore direct stress $= \frac{25,000}{300} =$ 83 lb./in.^{2}

Now, referring to Article 69 for nomenclature,

$B = \frac{10,300}{300} = 3,433$ as before.

The expression KC, which stands for the stiffness of the column, is made up of two parts, one above the floor, and one below the floor.

For the former, $K=6$, $C=\frac{7090}{150}=4,700$

whence $KC =$ 28,200

as in Article 69.

Similarly the lower tier of column has $KC =$ 28,200

Hence the total KC, as affecting the joint between column and third floor beam is $KC = 56,400$.

Whence $\frac{KC}{B} = \frac{56,400}{3,433} = 16{\cdot}4$.

From Table II. Section 69, the moment at the joint due to this is $\cdot 072\ Wl$ or $M = \cdot 072 \times 25,000$ lb. × 300 in. = 540,000 in./lb.

Clearly half this moment is carried by the upper length of column, and half by the lower length, so that the section under third floor only carries $M = 270,000$.

The stress due to this is $\frac{My}{I}$ as in Article 69, and in our case, is

$$\frac{270,000 \times 8}{7,090} = 305 \text{ lb./in.}^2$$

so that the max. stress in $305 + 83 = 388$.

It will be seen that while the direct stress is double (as this lower column carries two floors instead of one) the bending stress is much reduced, and the total stress is less. If we investigate the stresses under the lower floor still, we shall find we get

direct stress	124·5
bending ,,	305
	429·5

and so on.

It will be seen from this that in outer columns, the stress is often greatest under the topmost floor or roof, and that the section required here will also be strong enough for several tiers down, and in buildings of not more than six storeys, the outer columns are often with advantage made the same size from top to bottom.

Even where a slight reduction of stress tempts a designer to vary the section, it must be remembered that a constant section enables the same column boxes or shutters to be used again, which is often a more important consideration than the saving of a few inches of concrete.

The writer has just designed a large building in Shanghai where all the columns were 22 in. square from top to bottom, interior and outside alike. Not only are the column boxes used many times—saving time as well as money—but the beam boxes are also of the same length on all floors, whereas an alteration of size of columns involves making the beams a few inches longer on each successively higher floor. The only variation was in adding a little more steel to the lower tiers of columns.

71. In the case of interior columns, the bending generally plays a less important part. The Table of Moments in interior columns (Table III. par. 69) may be used, and it should be particularly noted that in this table W is the *live load only* (since the dead load is balanced), whereas for Table II. and outer columns W is the *total load*, since both the live and dead load produce deflection and bending on the column. It must also be remembered that for interior columns, the condition for bending of columns is when one panel on one side is loaded and that on the other is unloaded, and under these conditions the direct stress on the column is of course less. Bending moments on interior columns may therefore often be neglected without great risk, while in outer columns to do so is criminally dangerous.

72. Although the deflection of a beam causes bending in an outer column, and obviously increases the stress on the inner edge thereof, many structures have been designed and built without this bending stress having been allowed for. Of these structures a few have collapsed while others have stood. Of those that have stood, many have never had the load for which they were designed. Thus a bedroom 20 ft. × 10 ft. designed for 70 lb. per ft., is designed for 200 × 70 = 14,000 lb. or 6½ tons. It is never likely to carry more than

4 people at 1½ cwts.	=	6 cwts.
2 beds at 1½ cwts.	=	3 cwts.
other furniture, say		11 cwts.
		—
		20 cwts.

One ton as against 6½ tons.

There remain nevertheless certain structures which have carried the load for which they were designed and yet were not calculated for bending in their columns. If these have stood well, and it can be shown that the actual stresses (calculated correctly) are considerably higher than usually allowed, then clearly these higher stresses were safe.

Or otherwise put, if a column which, incorrectly calculated, appears to be stressed to say 500 lb./in.^{2}, is correctly calculated and shows 1,000 lb./in.^{2}, it obviously has not become less safe. More accurate calculations must stand for more economical, not more extravagant, structures, and obviously a more accurate system of calculation giving apparently greater stresses, must be accompanied by a raising of permissible stresses.

Put yet another way, a nominal factor of safety of four, which owing to elastic limit of steel and low strength at one month of concrete may be considered to be a real factor of say 2½, obviously contains a large margin. Part of this was to allow for errors of calculation. Clearly, when one of the chief errors is eliminated, a lower factor is called for.

The author is satisfied that when all secondary stresses are accurately calculated, stresses may be raised at least 25 per cent. above those ordinarily used [20,000 steel and 750 concrete instead of 16,000 steel and 600 concrete] not only in columns, but throughout the structure, and even then produce safer and stronger buildings than when lower stresses and a wrong system of calculation are adopted.

A NEW REINFORCED CONCRETE ACID TOWER FOR THE RIORDON COMPANY, LIMITED, HAWKESBURY, ONTARIO, CANADA.

THE above building, of which we publish illustrations, is for the preparation of acid for use in the paper mills. The building itself is principally interesting owing to the use of moving forms for the construction of the walls. This method, although almost universally used for deep bins in grain elevators, etc., in Canada and the United States, is not so well known in England.

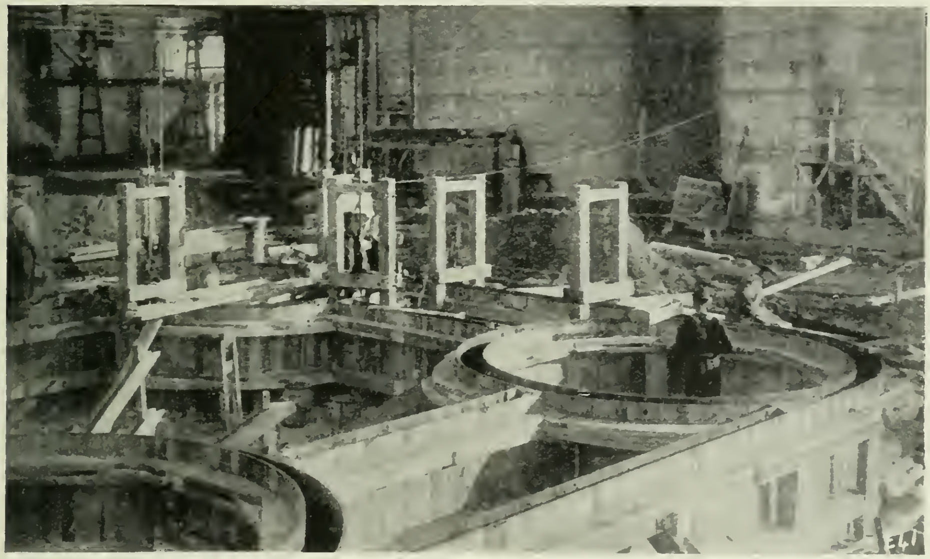


Fig. 1. Moving Forms in Process of Erection.
ACID TOWER, HAWKESBURY CANADA.

The plan of the building consists of four circular concrete tanks, each 13 ft. external diameter with 9-in. walls, centre of tanks 22 ft. apart, height of tanks 100 ft. from foundation slab ; above the tanks the outer quadrants were joined by straight walls and continued up for another 15 ft., making a total height of 115 ft.

The central space, enclosed by the towers and curtain walls connecting adjacent towers, is used for a stairway and is divided into storeys by floors. The upper part of building above the top of tanks consists of two floors containing nests of pipes used in the manufacture of the acid. The four towers will be filled with limestone rock which is fed in at the top of tanks and sinks down a few feet a day owing to the action of the fumes passed through it.

Fig. 1 shows the moving forms in process of erection on the foundation slab. Pouring of concrete was commenced in these forms on October 8, 1920, and proceeded at an average rate of over 4 ft. per day up to the top of the building, 115 ft. above this point.

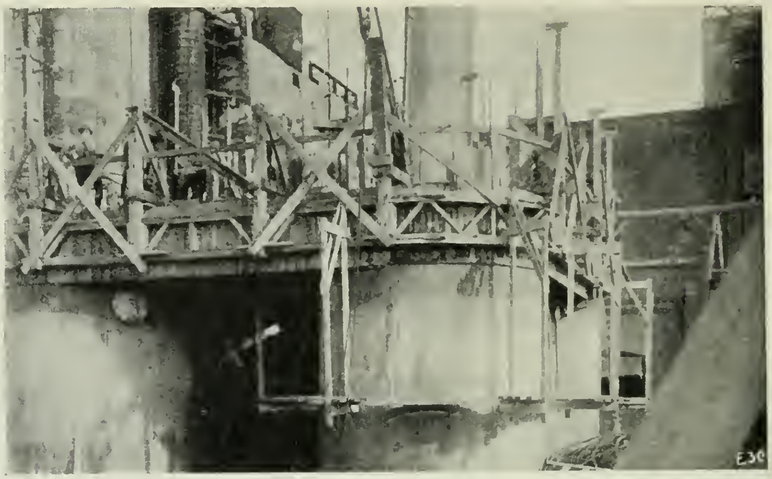
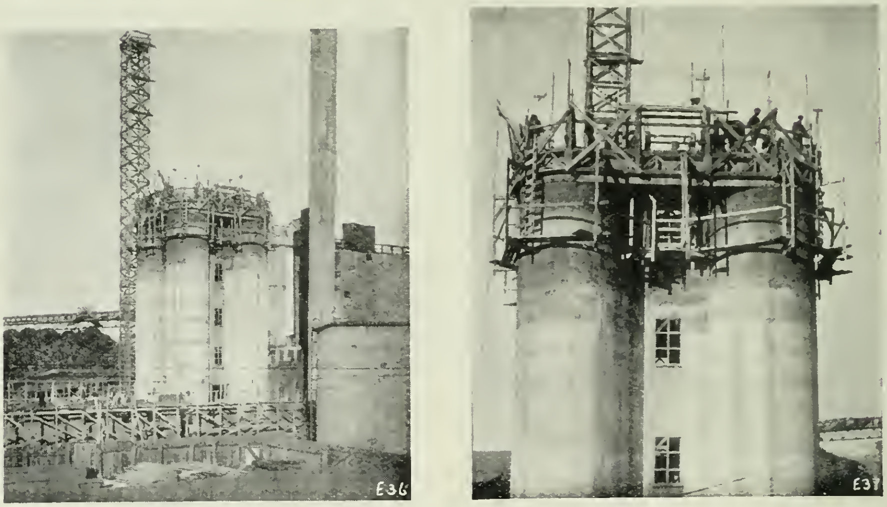


Fig. 2. Towers in Course of Erection.



Figs. 3 and 4. View of Towers 69 ft. above Elevation Slab.

Fig. 2 shows the towers 17 ft. above foundation slab.

Figs. 3 and 4 show the towers 69 ft. above foundation slab.

Fig. 5 (*page* 196) shows the moving form work completed and the forms for cornice partly erected. The moving form work 115 ft. above foundation slab was completed on November 5, or twenty-eight days from the commencement.

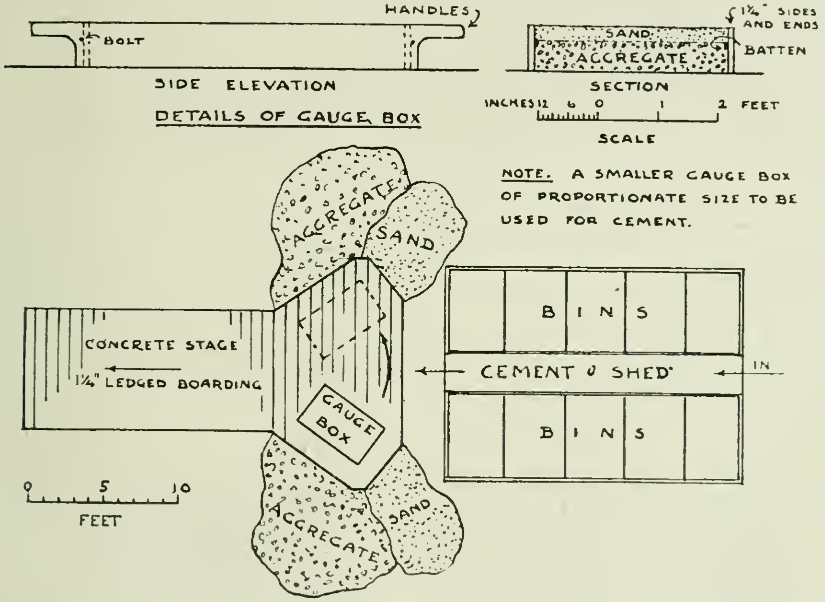
The designs for the reinforced concrete of these towers were made by the John S. Metcalf Co., Limited, of Montreal, Canada ; this Company also carried out the construction work.

THE USE AND ABUSE OF A CONCRETE STAGE.

A short article of interest appeared in a recent number of "Housing" under the above title. We would particularly draw attention to the valuable suggestions contained in the latter part of this article.—Ed.

If present intentions are carried out and a portion of our unemployed are drafted into the building trade, the concrete stage will play an important part in finding work for these men. Concrete work has often proved a failure, and many of these failures are due to the improper manner in which the materials have been mixed. To obtain good hand-mixed concrete the first consideration must necessarily be the stage, how, and of what size, to make it.

The stage should be made up in sections and ledged together, the boarding or decking being grooved and tongued to prevent wastage of cement. In shape it should resemble the letter Y, the wings of the Y being formed to allow a gauge box to be charged on each wing alternately. The stage should be placed on timbers or deals levelled on the ground. The length of the stage should be ample to give room for easy work and to keep a gang of concretors constantly employed. The length will usually be about 26 ft. over all, the width 8 ft., and the wings of the Y sufficiently long to take a 5 ft. 3 in. gauge box. The organisation rendered possible by laying down a stage of this kind very soon repays its cost.



NOTE. A SMALLER GAUGE BOX OF PROPORTIONATE SIZE TO BE USED FOR CEMENT.

By courtesy of "Housing."

The gauge box should not be a large square box, a half-yard cube gauge will be found the most convenient for working, the size being about 5 ft. 3 in. × 3 ft. 3 in. × 9½ in.; when in use, its length is laid parallel to the stage. A yard gauge will often intimidate the concretors, but a half-yard gauge is not so alarming.

The aggregate and sand should be at the wing end of the stage and as near it as possible. The cement store should be placed between two heaps of aggregate and sand, as shown in the plan, the store being divided up into bins with a way through the centre. It is advantageous to unload the cement into bins because it is then easier to load the cement gauge box and the sacks can be returned in proper sequence immediately the cement is binned.

The next consideration is the organisation of labour. The number of men required for mixing depends on the speed at which the mixed concrete is wanted; but, assuming it is wanted at top speed, the following men will be required: two to load the gauge box with aggregate, sand, and cement, eight to turn, and one to water the mixture. The gauge box should be loaded on one wing of the stage, and, while the mixture is being turned, the box is loaded on the other wing, and so on. The first pair of mixers will turn the concrete dry; it is then again turned by the second pair; the water is then added, the third and fourth pair turning the material wet to complete the gauging. The watering-pot should always be provided with a rose, and the amount of water required for a gauging ascertained so that the concrete will all be of the right consistency. This method of mixing concrete has many advantages. The men always know their places, the gauge box is not too deep and allows a good area for spreading the cement, a shovel will pick up the whole depth at one operation, the concrete is on the move all the time and at the finish is properly mixed, accurate costings can be kept, and when the men have learnt the knack of turning the shovel correctly concrete can be cheaply mixed.

Taking the other side—the abuse of the concrete stage. It often happens that the stage is made up of a few rough timbers laid carelessly on the ground; this stage is usually far too small; so many barrows of aggregate and sand are heaped on the so-called stage, a bag of cement is then placed on the top of the heap and the turning is begun, the water being thrown on by means of an ordinary bucket.

As a result, a great portion of the cement is washed away and the proportions are in consequence something like 12 to 1 when they should be, say, 6 to 1; the concrete never is and never can be thoroughly mixed; there is no room to prepare another gauging, so that half the men are idle; concrete sacks get lost and are costly to replace at the present time; and there are other evils too numerous to mention.

Concrete well and properly mixed is one of the best of building materials. Concrete badly mixed is highly dangerous.

E. J. I.

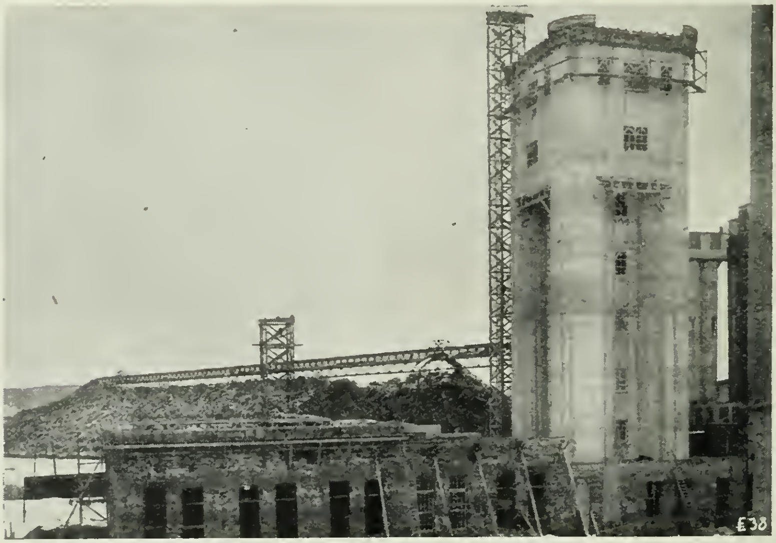


Fig. 5. Moving Formwork Completed.
ACID TOWER, HAWKESBURY, CANADA.
(*See page* 193.)

CEMENT NOTES.

By Our Special Contributor.

The "Killing" of Portland Cement.

"KILLED" is the term used to describe concrete when the setting of the cement has been disturbed in such a way as to retard the hardening.

Although the mechanism of the setting of cement is not a matter on which experts agree, there is a fair consensus of opinion that the initial stages of setting are due to crystallisation, and upon the assumption that this is correct it is easy to imagine that when concrete is disturbed after setting has commenced, the interlocking crystals, causing the stiffening of the mass known as initial set, become broken up and possibly partially re-dissolved so that a new formation of crystals is necessary before setting can proceed. This takes time and thus leads to retarded hardening.

In some cases, however, it happens that a "killed" concrete remains permanently deficient in strength, and this may occur when frost intervenes and causes a further disintegration of the crystalline formation, or when through lapse of time the amount of water in the concrete required to complete the hardening has disappeared through evaporation or absorption. This possibility emphasises the desirability of keeping concrete moist for a week or so after laying.

The fact that concrete is being "killed" is always apparent to an intelligent workman engaged in the mixing and laying of the concrete, but is not always revealed to the man in charge.

It is usually a difficult matter to prove from an examination of concrete that "killing" is the cause of lack of strength, and concrete failures are frequently attributed to this cause only after a process of elimination of other causes. A concrete expert can, however, in some cases recognise a characteristic appearance of "killed" concrete.

Prevention of "killing" is of course better than cure, but it may be useful to mention here that "killed" concrete can frequently be improved by applications of a solution of silicate of soda.

"Killing" may of course be prevented by completing the mixing and deposition of concrete before setting commences, and here it becomes necessary to define the period known as commencement of set.

The initial set as defined by the British Standard Specification implies that the cement has acquired a certain consistency sufficient to resist the penetration of a needle of definite weight and dimensions, but every cement tester knows that the actual setting as evidenced by stiffening—probably crystallisation—commences some time before the initial set as recorded under British Standard Specification testing conditions.

It is not uncommon to find cements having British Standard Specification initial sets of 90 minutes coupled with final sets of 150 minutes, and although cement manufacture has made advances in recent years there are few who would claim that these figures truly represent the commencement and finish of setting.

The fact is that British Standard Specification tests are founded on an arbitrary basis and are doubtless the best standard that can be devised with present knowledge, but in the writer's view it is unwise to accept the initial set period as the permissible time for mixing and depositing concrete.

When weak mixtures of concrete are used in the open air during cold weather, it is probable that the British Standard Specification initial set period is a safe one because the actual setting test is made at a minimum temperature of 58° F., and with the minimum proportion of water to produce plasticity, whereas the lower external temperature and the larger proportion of water used in practice, especially with weak mixtures, both tend to retard the commencement of setting.

But the conditions are reversed in the summer, and the risk of relying upon the B.S.S. initial set test then becomes a serious one.

There is, however, another aspect of the "killing" of cement which must be considered, and this is that large amounts of concrete have been placed, in which the cement has been "killed" without any apparent disadvantage. Cement made by the chamber kiln process some fifteen or twenty years ago frequently had an initial set of ten minutes or less, and in the early days of rotary kiln manufacture great difficulty was experienced in producing a cement with more than five minutes initial set.

With such setting qualities it was practically impossible to avoid " killing " the cement, and it is no exaggeration to state that hundreds of thousands of tons of quick setting cement have been " killed " in use without any apparent harm.

Laboratory tests can be cited which demonstrate that under certain conditions " killed " cement is as good as cement properly used, and an illustration can be given by quoting the following tests given by Candlot in his *Ciments et Chaux Hydrauliques* :—

Tensile strength at seven days of a mixture of three parts sand to one part cement :—

Normal mixing—19·5 kilos. per sq. cm. = 277 lb. per sq. inch.

" Killed " mixture—22·2 kilos. per sq. cm. = 315 lb. per sq. inch.

The conditions under which cement can be " killed " without harm have still to be determined, and in the meantime the user of cement would be well advised to avoid " killing " by placing his concrete as soon as possible after the cement comes into contact with water. *Inter alia*, this implies that cement and damp aggregate must not be in contact until required for conversion into concrete and that no mixed concrete should be allowed to stand during workmen's meal-times awaiting deposition.

Portland Cement *v.* Lime.

The relative values of Portland cement and lime is a subject of perennial discussion among engineers. In the end, the prices and availability of the two materials usually decide the question as to which should be adopted for mortar-making purposes.

Price alone is however not a fair criterion on account of the greater strength possessed by cement mortars above lime mortars, and in some results published in Germany, the factors of price and strength are both taken into account by adopting as a comparison a simple fraction of which the strength of a brickwork pier in kg. per sq. cm. is the numerator and the cost of the structure per cubic metre is the denominator. By constructing and testing brickwork piers with cement mortar and with lime mortar some interesting figures have been obtained.

If ordinary lime mortar (one lime to three sand) be taken as unity, cement mortar (one cement to four sand) gives in the above fraction the figure 2·12, thus showing that cement mortar can be used to considerably greater advantage than lime mortar taking both cost and strength into account. (*Engineering Abstracts.*)

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Handbook of Building Construction. 2 vols. Editors-in-Chief: George A. Hool and Nathan C. Johnson. Publishers: Messrs. McGraw-Hill Publishing Co., Ltd., 6 & 8 Bouverie Street, E.C 4, and New York, U.S.A.

Price £3 the two vols.

These two volumes bound in flexible leather, clearly printed and well illustrated, predispose the reader to a satisfactory judgment, and after a closer acquaintance, one's only regret is that they are based on United States practice and are not universally applicable to the requirements of the British reader.

As a handbook of building construction, the work is most comprehensive, and in some sections exhaustive, so that one envies his American confrere who can have such a mine of information by his side.

The first volume commences with the elements of structural theory and sets out clearly the principles involved in calculating strengths of beams, columns, trusses, etc., in timber, steel and concrete. This section should be of considerable benefit to the student and to the practical man who has not had the advantage of a technical education but is willing to take pains to learn first principles. Then follows a section on the designing and detailing of structural members including adequate treatment of reinforced concrete.

Succeeding sections give a wealth of structural data covering nearly 500 pages and providing much detailed information respecting foundations, piling, floors, roofs, chimneys, etc., and then specialising into the design of public and industrial buildings, farms, etc. Methods of construction and construction equipment are discussed and well illustrated, followed with a section on building materials containing admirable articles on concrete and concrete aggregates by Nathan C. Johnson, whose name is familiar to readers of this Journal.

Estimating and contracting are somewhat briefly dealt with in fifty pages, and the work concludes with some 300 pages on mechanical and electrical equipment of buildings, including water supply and sewage disposal.

The volumes have been compiled by a staff of forty-six specialists, and the name of the writer is given over each section. With so many contributors on similar subjects it is difficult to avoid inconsistencies; thus on page 610 it is stated that "the use of solid concrete for walls above grade is not generally considered advisable on account of . . . the tendency of concrete to absorb moisture and cause damp walls on the inside," while on p. 685 occurs the statement that "reinforced concrete is the most suitable material for many retaining walls because of the possibility of making it moisture proof."

As already indicated, the value of the handbook to the reader in this country is reduced on account of the materials, viz., timber and various machines and fittings being those common in America but not in the United Kingdom, while the rules and formulæ relating to reinforced concrete and other constructional work are those drawn up by American Authorities, and although quite satisfactory in their way, they cannot be adopted by the British engineer, who must necessarily obey the rules and customs existing in his own land.

In some respects the handbook is an encyclopedia, and the wisdom is rather doubted of attempting to set out in thirty pages not only electrical theory, but a description of electrical wiring which may induce an amateur to undertake work which should only be executed by one with expert knowledge.

Similar comments might be made on the sections on boilers and chimneys, while in the water supply section only one of the numerous water softening methods is discussed.

Concrete receives the full treatment its importance deserves in the handbook, but the section on cement might well be revised by a cement manufacturer before the next edition is published. Such a revision would result in the paragraph on seasoning of cement being deleted, for such treatment should now be quite unnecessary. Also, Portland cement is not burnt "to a point somewhat beyond" the commencement of fusion, while "steel Portland cement" is probably intended to mean "eisen" or "iron cement," which is Portland cement (produced partly from slag as a raw material) with slag as an adulterant.

In the paragraph on concrete pile foundations, a reference is made to piles containing less cement than one part cement to two parts sand as being susceptible to frost, and it is not clear whether this is an error or whether coarse aggregate in addition to the sand is implied but not mentioned.

These small defects do not detract from the value of the handbook as a whole, and indeed it would be surprising if in a work of 1400 pages it were not possible to indicate one or two possibilities of improvement.

Subject to the limitations imposed by its American origin, the handbook can be recommended as a most useful work of reference to all concerned in constructional work.

"Tonindustrie Kalender, 1921."

The "Tonindustrie Kalender" for 1921 presents its usual appearance and contains the same general information as usual. The new matter consists of a rather more lengthy "Table of Purposes for which Seger Cones may be used," a description of the Hirsch electric furnace for determining sintering and fusion temperature, a glossary of materials used in the cement and other clayworking industries, and a Table showing the temperatures attained in industrial furnaces.

The greater part of the Kalender is occupied by a useful "Buyers' Guide" which covers nearly 200 pages.

A NEW CONCRETE MIXER.

THE "TONKIN" MIXER.

THE necessity for good concrete, and the fact that the mixing operation is one of the vital factors in the production of good concrete, have been consistently urged by the professional and research bodies, and are now realised by all who have the interests of soundly-constructed concrete buildings at heart. It is also generally realised that a much better result is obtained when the materials are mixed by machine than when the costly and uncertain method of hand-mixing is adopted, and of late years considerable headway has been made in the design of concrete mixers, chiefly, however, of the revolving drum type.

We recently had an opportunity of seeing in operation a mixer designed on an entirely new principle, the invention of Mr. G. A. Tonkin, which has been put on the market by the Tonkin Mixer Company, of 608, Salisbury House, London Wall, E.C. Mr. Tonkin, who is also the inventor of the well-known "Australia" concrete block-making machine, has had considerable experience of concrete work, and realises that one of the first essentials of machinery to withstand the wear and tear of use on a building contract, and which is to be handled by unskilled labour, is simplicity.

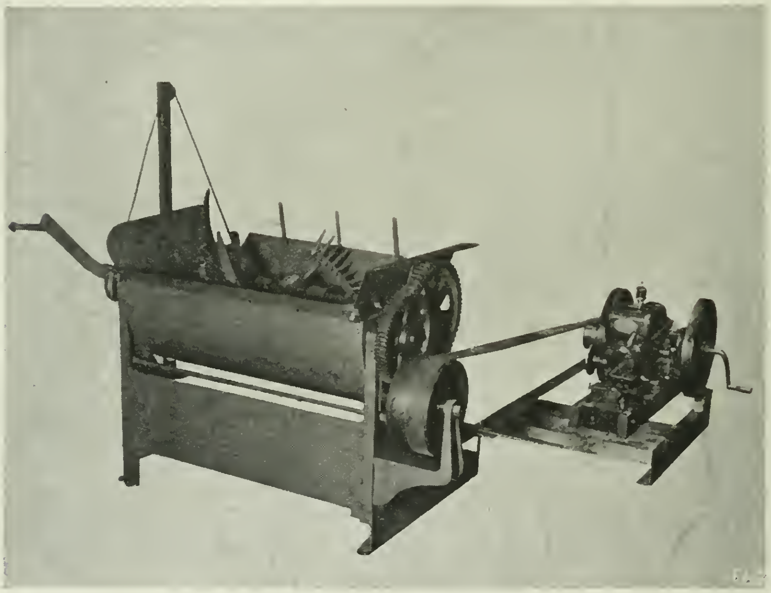


FIG. 1. THE TONKIN MIXER.

As will be seen from the accompanying illustrations, the machine has very few working parts. The materials are mixed by two revolving rakes attached to an axle set horizontally across the drum, and so arranged that when revolving they follow each other on the worm principle, turning the materials from the ends of the drum to the centre. At each revolution, therefore, the whole of the contents come together in the centre and drop to the bottom of the drum. The rakes revolve at the rate of twenty-five times per minute, and a dozen revolutions are sufficient to mix a batch; every particle contained in the drum is turned, kneaded and raked at every revolution, and the result is a very thorough mix. The materials are in view during the whole of the operation, and as the mixing process can be observed during the whole of the period there is no possibility of their being discharged before a satisfactory mix is obtained ; neither, on the other hand, is there any possibility of time being wasted by over-mixing.

The materials are tipped into the drum from a hand-barrow running up an inclined track on the engine side of the machine, and discharged from the other side. The mix is discharged by tipping the drum by means of a small winch at the opposite end to the drive (*Fig.* 2 shows the machine in the discharging position). The rakes revolve from the back (or discharging side) of the drum to the front, and help to clear the drum when it is tipped ; there is no necessity to stop the machine while it is being discharged, and thus a continuous output is maintained.

The machine has a capacity of three cubic feet per batch, and without the power drive, but fitted with a handle at each side, is a cheap and efficient means of mixing concrete for even the smallest job. With the power drive, and by reason of its continuous operation, it has a very large output, and we are informed that one working on the construction of a large reinforced concrete building in London is turning our 90 cub. yds. of concrete per eight-hour day. It can also be used for mixing other materials, and several are now in use by local authorities for mixing road materials—it is specially suitable for mixing tar macadam.

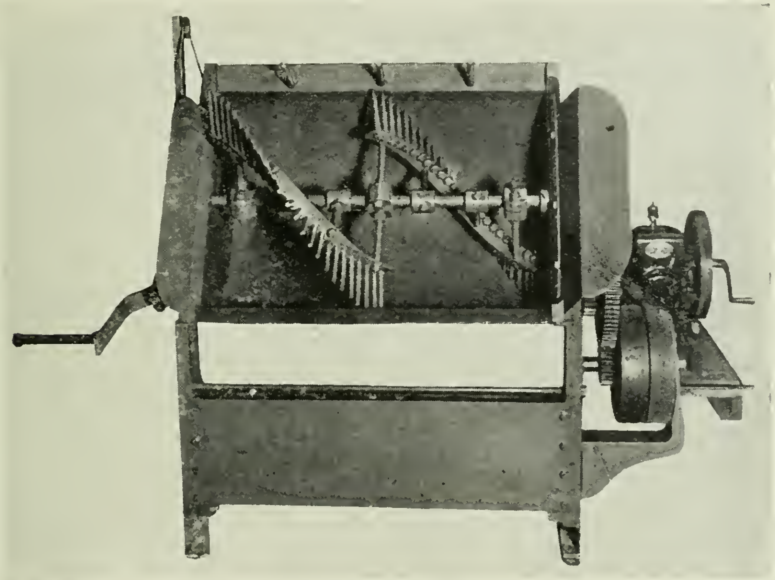
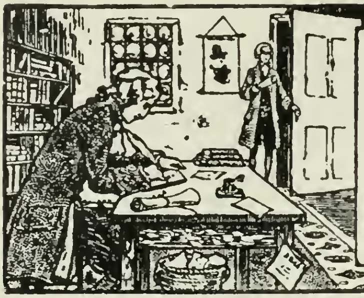


FIG. 2. THE TONKIN MIXER.

The "Tonkin" mixer will go a long way towards overcoming the objections sometimes heard that the output of small concrete mixers is proportionately small, and that the large mixers are so complicated as to require skilled supervision, are costly to buy and to run, and difficult to transport from one site to another.

The machine, complete with oil engine, is at present sold for £100 ; with power attachments, but without engine, the price is £60 ; and fitted with a handle at each side for hand operation, the price is £50. The cost of renewals should be extremely low ; with the exception of the engine and drive the only parts subject to any large amount of wear are the teeth on the rakes, and these can be renewed separately as required.

Composite Concrete Construction Company.—We are asked to state that the address of this firm is 51, *Pall Mall, S.W.*1, and not, as stated in our February issue, 11, Duke Street.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—Ed.

ROAD NOTES.

Road Constructional Requirements from the User's Point of View.—In the course of a lecture recently delivered to graduates and students of the Institute of Transport, Col. Bressey, Divisional Engineer, London Roads Branch, Ministry of Transport, said :

The modern user of highways naturally expects, in return for his contribution towards the cost of road upkeep, that his requirements shall be borne in mind in the design of new and the improvement of old highways, the present condition of which, in his eyes, leaves much to be desired.

In the forefront of the motorist's grievances one may probably place the perpetual interruptions of traffic caused (*a*) by the opening of streets, and (*b*) the renewal of road surfaces, the former arising from the multitude of mains, conduits, sewers, drains, etc., buried under the paving, and the latter from the use of insufficiently durable materials. The two causes are, however, closely interrelated, for, however great the precautions adopted in making good the trenches cut in a road, a weak spot is almost invariably left, which shortens the life of the paving. Indeed, it may be questioned whether in the narrow streets of busy towns the materials used for paving are ever given a fair chance of displaying their durability, owing to the perpetual excavations to which the streets are subjected. Much might be done to mitigate this annoyance.

The gradual replacing of waterbound macadam by surfacing materials of greater durability is proceeding apace, and the recurrent renewals of road crusts are therefore taking place at longer intervals.

Owing to the rising cost of labour, local authorities fortunately show an increasing preference for permanent materials which occasion a minimum of wage expenditure for scavenging and upkeep.

The reduction of tractive effort by the adoption of a smooth, even surface is of high importance to road transport, and the avoidance of steep gradients is an almost equally weighty consideration. A maximum gradient of 1 in 30 is often quoted for non-mountainous districts, and a minimum gradient of about 1 in 250 is desirable for the proper drainage of the road. The camber, or convexity, of the carriageway should not exceed 1 in 30, and where there is a longitudinal gradient the camber may be reduced to a much lower figure. American engineers are in many cases adopting a scarcely perceptible camber for the new concrete roads to which so much attention is now being devoted.

Easy curves are essential ; an ideal often quoted by engineers on the Continent is a minimum radius of 550 yards, although in many hilly districts where hairpin bends are inevitable a radius of only 100 ft. is found.

For the safety of traffic, an unobstructed sight line of at least 100 yards is recommended, and this consideration implies the smoothing out of gradients at summit point on hilly routes.

Bath's Concrete Roads.—The General Purposes sub-Committee reported that, in view of the sanction of the Ministry of Health to the construction of the reinforced concrete roads at London Road and Lower Bristol Road, to which they would contribute half the cost, it was recommended that arrangements be made that Mr. E. Ireland lay reinforced concrete in these roads on the same terms that he was now laying concrete in the Lower Bristol Road.

Mr. Sealey asked if the Committee had received any report as to the wear of the reinforced concrete, which was new to them.

The Chairman replied that the Surveyor recommended it, and he (the Chairman) did not think there was any question about the wear.

The City Surveyor was asked to give his opinion. He said they had no actual report from other towns, but experience proved that reinforced concrete was satisfactory.

Reinforcement of Concrete Roads in California.—In reinforcing some of the concrete roads in California what is known as the two-operation method has recently been applied. A mesh reinforcement is used and the operation is as follows :—

The mesh is shipped to the job in flat sheets cut to the proper length. Mixing operations are then begun and the lower half of the slab is poured for a convenient length (section one). Where a spout mixer is used this first pouring is from the end of the spout. A gate in the middle of the spout is then opened and the space next the mixer (section two) is poured on the sub-base in the same manner. During this second operation the fabric is laid on section one and, without moving the mixer, the top half of section one is poured over the mesh from the outer end of the spout.

The mixer is then advanced a distance equal to the length of a section and while the lower half of section three is being poured from the gate in the middle of the spout, sheets of fabric are laid over the lower half of section two. The gate in the middle of the spout is then closed and the fabric of section two is covered with its top layer of concrete by pouring from the end of the spout. This process is repeated during the remainder of the job, two adjoining sections of half thickness, one at the top and one below, being poured from each mixer position.—*Engineering News Record.*

Another method recently adopted on forty miles of concrete road was the following :—In this case ¾ in. deformed steel bars were used, placed transversely on 18 in. centres. It having been found, on California highways, that triangular sections will ravel out readily where transverse cracks reach the edge of the road, these points are strengthened by using longitudinal runs of ¾ in. bars, laid with the joints alternately butted and lapped and butt joints brought half way between the adjacent transverse bars.

In placing these bars so that they are supported at the proper height from the subgrade, short lengths of pipe are used. As the concrete is poured the pipes are withdrawn. These sections of pipe are fastened to the concrete mixer by a wire or chain and as the mixer moves along the pipes are pulled along with it. Hooks hung on the headers or short pieces of 2 by 4 in which a slot is cut for holding the rods at the proper height and distance from the edge of the pavement support the longitudinal rods during the pouring of the concrete. As the paving progresses the wood blocks may be moved along. The end of the transverse bars are bent and hooked over the longitudinal bars where they are securely tied. Four sections of pipes in a rigid fan shape hold the rods in position while pouring the concrete on wider pavements than the standard.

GENERAL NOTES.

Cement Linings of Water Flumes.—Some experiments carried out in connection with the water flumes, or wooden distribution troughs, on the Waterford (U.S.A.) Irrigation District have convinced the authorities that a considerable saving in both initial cost and maintenance charges can be effected by the use of cement linings to the flumes, and such satisfactory results have been obtained that the system is to be extended. A wire mesh is placed along the bottom and sides of the flume, and kept about ⅜ in. from the timber. On this mesh a cement plaster is coated to a depth of one inch, the plaster consisting of one part cement and three parts sand. In the case of flumes where the timber is decayed the insertion of such a lining would be considerably cheaper than renewing the timbers, and in the case of new flumes a much lighter timber construction can be used. As a result of the experience gained it is recommended that expansion joints be provided to allow of not only the expansion

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In carrying out their Contracts in the most Efficient and Economical manner, should write for the following catalogues :—

No. 80. Steel Sheet Piling.
No. 81. Pile Hammers and Complete Driving and Withdrawing Equipment.
No. 82a. "Zenith" Friction Winches.
No. 70. "Zenith" Concrete Mixers.
No. 82. "Zenith-Pup" Concrete Mixers for Small Users.

THE BRITISH STEEL PILING CO.

DOCK HOUSE, BILLITER STREET, LONDON, E.C.3.

and contraction of the lining, but also for the expansion and contraction of the wood to which the lining is attached, which will, of course, be more variable in movement than the cement. In the flumes built on this sytem no longitudinal cracks have appeared.

Concrete Chimneys.—Several large reinforced concrete chimneys have recently been completed in the United States, in which a novel form of construction has been adopted. From a brief account before us, it appears that a steel mast is first erected to the required height and the chimney built around it. The mast carries a working platform, which is raised as the work proceeds, and also radiating steel tees by which it is possible to preserve the lines of the chimney and uniformity of taper. The shuttering is of sheet steel with angles made to overlap as the diameter of the chimney decreases. No scaffolding either inside or outside the stack is used. It is stated that the system considerably reduces the cost of construction. An instance is given of a stack 5 ft. by 4 ft. by 100 ft. being completed in twenty-one days by four men.

Gas Engine Exhaust Silencer.—A novel use for concrete which has given satisfactory results is represented by the construction of an exhaust silencer for a large gas engine installed for pumping at one of the wells of the Standard Oil Co. in the United States. The silencer is described as a concrete chamber 4 ft. square by 8 ft. deep, with the top sloping inwards and leaving an opening about 8 in. square. The chamber is embedded in the ground about 5 ft. below the surface. Exhaust gases from the engine are led into the chamber through an underground pipe connected near the bottom of the silencer, the exhaust escaping through the top opening with very little noise, as the concussion of the explosions is absorbed by the concrete and the solid backing of earth on all sides. It is stated that gas engines with concrete silencers can be installed quite close to offices and dwelling-houses without causing any nuisance, and that the cost of construction is very much less than that of metal or timber silencers, particularly in places where sand and gravel are found on the site.

A Concrete Coaster Launched at Preston.—The concrete ship *Burscough*, the first of two being built by the Ritchie Concrete and Engineering Shipbuilding Co., Ltd., at their yard on the Ribble, has been successfully launched at full tide. The two vessels are for Messrs. Tyrer's Coasters, Ltd., of Liverpool and Preston. The *Burscough* has been built on the Ritchie United System of reinforced concrete construction and has a length of 124 ft., width 23 ft., and moulded depth 12 ft. She will have a load draught of 10 ft. 6 in. Her registered tonnage is 143, and the dead-weight carrying capacity 300 tons. She is designed for a speed of nine knots, fully laden, at sea, being a single screw ship fitted with internal combustion marine oil engines of 240 brake horse-power. Accommodation for the personnel of the ship is afforded on the deck level.

The International Building Trades Exhibition.—Among the firms exhibiting at this Exhibition this year are the following :—

Associated Portland Cement Manufacturers, Ltd.
Australia Concrete Block-Making Machine Syndicate, Ltd.
British Everite & Asbestilite Works, Ltd.
British Fibrocement Works.
British Portland Cement Manufacturers, Ltd.
British Roofing Co.
British Steel Piling Co.
Builders' & Contractors' Plant, Ltd.
Building Products, Ltd.
Cement Marketing Co., Ltd.
Climbing Steel Shuttering Co.
Concrete Dwellings, Ltd.
Crittall Mfg. Co., Ltd.
Edwards Construction Co., Ltd.
Expanded Metal Co., Ltd.
Fawcett Construction Co., Ltd.
Feroda, Ltd.
Fireproof, Ltd.
F. McNeill & Co., Ltd.
Grovesend Steel & Tinplate Co., Ltd.
G. R. Speaker & Co.
Hayter, Ltd.
Henry Wilde.
Ironite Co., Ltd.
Johnson's Reinforced Concrete Engineering Co., Ltd.
Kerner - Greenwood, Ltd.
Kleine Patent Fire Resisting Flooring Syndicate, The, Ltd.
Liner Concrete Machinery Co.
Manelite Patent Concrete Machinery Co., Ltd.
Metacon Patent Glazing Bar Co., Ltd.
Modern Building Co.
Moler Fireproof Brick & Partition Co., Ltd.
Ransome MachineryCo., Ltd.
Rawplug Co., Ltd.
R. G. Whittaker, Ltd.
R. H. Kirk & Co.
Ruberoid Co., Ltd.
R. W. Blackwell & Co., Ltd.
Self-Sentering Expanded Metal Works, Ltd.
Sharp, Jones & Co.
Siegwart Fireproof Floor Co., Ltd.
Stothert & Pitt, Ltd.
Sutcliffe, Speakman & Co., Ltd.
Thermos Flooring Co , Ltd.
Torbay & Dart Paint Co., Ltd.
Tourba Construction Co.
Tuke & Bell, Ltd.
Wilfley Co., Ltd.
Winget, Ltd.
Wm. Bayliss & Co., Ltd.
Wm. Kennedy.

The Victoria CONCRETE MIXER

THIS illustration shows one of our concrete distributing plants designed to serve an area of 100 feet radius. The chuteing is divided into two sections, the outer section being balanced. By this means it is possible to deliver the mixed concrete anywhere within this radius, speedily and with a minimum of labour and effort. This distributing plant greatly simplifies the erection of large buildings and engineering works, and renders considerable economies possible.

THE plant illustrated here is now in course of construction to the order of a client.

PARTICULARS of this plant and of the "Victoria" Concrete Mixers to use in conjunction with it will gladly be supplied on request.

STOTHERT & PITT
LIMITED
(MIXER DEPARTMENT)
11, VICTORIA ST., LONDON S.W.1

Queensland's New State Cold Stores.—Among the public works in course of construction in Queensland are the State Cold Stores at Hamilton, on the Brisbane River, at an estimated cost of £249,000. The building is being constructed of reinforced concrete on concrete piles. The cold stores consist of two floors, the ground floor being divided into nine butter rooms, with a storage capacity for 150,000 boxes. On the upper floor are five cheese rooms, with a gross content of 158,400 cubic feet, and a storage capacity of 25,000 crates; and four fruit and egg rooms, with a storage capacity of 38,400 cases. This floor is to be worked by elevators from the railway platform and by gravity chutes to ships' holds. The insulation is to consist of 2 in. cork board manufactured at Brisbane from imported Spanish granulated cork.

Scientific and Industrial Research.—The Lord President of the Council has established an Inter-Departmental Committee on Patents with the following terms of reference :—

1. To consider the methods of dealing with inventions made by workers aided or maintained from pubiic funds, whether such workers be engaged (*a*) as research workers, or (*b*) in some other technical capacity, so as to give a fair reward to the inventor and thus encourage further effort, to secure the utilisation in industry of suitable inventions and to protect the national interest ; and

2. To outline a course of procedure in respect of inventions arising out of State aided or supported work, which shall further these aims and be suitable for adoption by all Government Departments concerned.

The Secretary to the Committee is Mr. A. Abbott, to whom all communications should be addressed at 16 and 18, Old Queen Street, Westminster, London, S.W.1.

CONCRETE AND HOUSING SCHEMES.

Beeston.—The Beeston Urban District Council is considering the erection of fifty concrete houses, at a cost of £918 each.

Chirk.—At a meeting of the Chirk Rural District Council, the Engineer stated that by the use of direct labour, and concrete or local stone, a saving of about £200 per house could be effected in the Council's housing scheme, as compared with the usual methods of construction.

London.—The London County Council has sanctioned the purchase of three "Winget" machines for the manufacture of concrete blocks on the Becontree housing site.

Musselburgh.—Owing to the high cost of the houses to be built in connection with the Musselburgh Borough Council's housing scheme, it has been decided to secure an economy by the use of concrete blocks in place of bricks, instead of reducing the number of rooms per house.

Newport.—The Newport Town Council has decided to put in hand as soon as possible the erection of a further 147 concrete houses on the Somerton housing estate on the "Duo-slab" system.

Oxford.—The Oxford Housing and Town Planning Committee has instructed the City Engineer to proceed with the construction of two concrete houses on the Botley Road site, and has recommended the City Council to acquire a site at the corner of Botley Road and Ferry Hinksey Road on which to build concrete houses by public tender.

Willesden.—The Engineer to the Willesden Urban District Council has submitted a favourable report to the Council on the concrete houses, on the "Fidler" system, recently completed for the Hayes Urban District Council, and the Willesden Council is considering the erection of similar houses in its own area.

Stanford-le-Hope.—The Orsett Rural District Council has decided to erect 100 concrete houses at Stanford-le-Hope.

NEW METHODS AND MATERIALS.

The following is a further list of materials and new methods of construction approved by the Standardisation and Construction Committee :—

The Weardale Steel, Coal and Coke Co., Ltd., Thornley Colliery, Co. Durham.—The "Hoop" Principle of Reinforcement for Concrete Houses.—The "Hoop" Principle of Reinforcement for Monolithic concrete walls is composed of 3 ft. by 1 in. by 3/16 in. octagon hoops, with angle stanchions, 6 ft. by ⅛ in. fixed between each hoop, forming a tie for the clinker blocks of the inner lining.

By this method of construction, all doors, windows and floor joists can be erected on the hoop framing before concrete work is started.

R. L. Bendall, 14, Richmond Wood Road, Bournemouth, Hants.—The Bendall Walling System.—With this system it is possible to construct the walls with concrete without timber shuttering, and, if necessary, with unskilled labour, by facing the exterior with clay or concrete tiles and the interior with clinker slabs tied together with high tensile steel wires, the cavity being filled with wet concrete.

W. McLeod, c/o Bank of New Zealand, 1, Queen Victoria Street, London, E.C.4.—A system of walling consisting of thin bottomless boxes of concrete or burnt clay. The main units are 12 in. long and 5 in. high, and of three thicknesses—4½ in., 7 in. and 9 in. These are laid breaking bond on top of each other without mortar and filled in solid with wet concrete.

PROSPECTIVE NEW CONCRETE WORK.

AMMANFORD.—The Ammonford Urban District Council is considering the erection of a new bridge, at a cost of £20,000.

BIRKENHEAD.—The Birkenhead Corporation has received sanction to the borrowing of £120,000 for extensions to the waterworks.

BO'NESS.—The Bo'ness Town Council is considering the construction of a wharf on reclaimed land from Bo'ness to Grangemouth, at an estimated cost of £3,000,000.

BUCKIE.—The Buckie Town Council has received Treasury sanction to the borrowing of £50,750 for the Harbour Extension Scheme.

BURNLEY.—The Burnley Corporation has applied to the Ministry of Health for sanction to a loan of £50,000 for the construction of a new reservoir at Hurstwood.

DUBLIN.—The Dublin Harbour Commissioners are considering the erection of a grain silo at the Harbour.

DUFFTOWN.—The Dufftown Town Council is considering plans submitted by Mr. Wittet, of Elgin, for a new 17,000-gallon reservoir.

GUILDFORD.—The Guildford Town Council is considering the construction of a reinforced concrete open-air swimming bath, at a cost of £8,000. The plans are for a pool 120 ft. by 45 ft. with pay office, attendants' room, etc.

ILFORD.—The Ilford Urban District Council has passed plans for the construction of a reinforced concrete coal store on the banks of the river Roding, for the Ilford Gas Company.

LIVERPOOL.—The Liverpool Corporation is considering the acquisition of 45 acres of land adjoining the Corporation's existing reservoirs at Prescot for the provision of a new reservoir.

NEWQUAY.—The Newquay Urban District Council has decided to construct a new swimming bath.

PENWITH.—The West Penwith Rural District Council has applied to the Ministry of Health for sanction to the construction of a new reservoir at Carbis Bay, at a cost of £6,000.

SALFORD.—The Salford Corporation has decided to proceed with a scheme of improvement and extension at the sewage works at Weaste, at a cost of £250,000.

WICK.—The Wick Harbour Trust is considering a scheme for the improvement of Wick Harbour, including the construction of two large breakwaters, at a total cost of about £1,000,000.

TENDERS ACCEPTED.

Concrete Houses.

ANNFIELD PLAIN.—The Annfield Plain Urban District Council has entered into an agreement with Messrs. William Airey & Son, Ltd., of Leeds, for the construction of concrete houses, on the "Duo-Slab" system. Under the agreement, the Company will receive a royalty of £5 per house for the first 100 houses and £3 per house in excess of that number.

BOOTLE.—The Bootle Town Council has accepted the tender of Messrs. R. Costain & Sons for the erection of 212 concrete houses at a total cost of £205,440.

LEEDS.—The Leeds Corporation has accepted the tender of Messrs. William Airey & Sons, Ltd., of Leeds, for the erection of 170 concrete houses at £835 for Type "A" houses and £950 for Type "B" houses.

THORNABY.—The Thornaby Town Council has provisionally accepted the tender of the Ben Baine Constructional Co. for the erection of five pairs of "B4" type houses on the "Leàn" system, at £2,130 per pair.

TORQUAY.—The Town Council has accepted the tender of Messrs. W. H. Smith for the erection of 40 non-parlour type concrete houses at £882 each for houses built in pairs and £815 each for houses built in blocks of four.

General.

LONDON.—The Lewisham Borough Council has accepted the tender of Mr. J. Pearce for the supply of Portland cement in connection with laying concrete foundations in Sydenham Road, at 90*s*. 6*d*. per ton. The Cement Marketing Co., Ltd., quoted the same price.

LONDON.—The Stepney Borough Council has accepted the tender of Messrs. D. T. Jackson for the construction of concrete foundations for a turbo-alternator at the Limehouse Electricity Generating Station, for the sum of £2,877 12*s*. 4*d*.

LUDLOW.—The Ludlow Rural District Council has accepted the tender of Messrs. Davies & Son, of Ludlow, for laying a concrete pavement at Craven Arms at 11*s*. 3*d*. per yard super.

NORWICH.—The Norwich Town Council has accepted the tender of Messrs. Constable, Hart & Co., of London, for 5,000 superficial yards of concrete for street works, at 14*s*. per yard.

TAUNTON.—The Taunton Town Council has provisionally accepted the tender of Messrs. Cowlin & Son, of Bristol, for the erection of a ferro-concrete bridge over the River Tone (from the designs of Messrs. Mouchel & Partners), at £12,192.

TENDERS INVITED.

Grays.—March 12. The Grays Thurrock & Bilbury Joint Sewerage Board invite tenders for the construction of 1,060 yards of concrete sewer tube, and other sewerage work. Forms of tender, etc., from Mr. Midgley Taylor, Engineer, 36, Victoria Street, Westminster, S.W.1.

Halifax.—March 12. The Halifax Corporation invites tenders for concreting and other work in connection with the foundations of two cooling towers at the electricity works. Plans, etc., from Mr. James Lord, Borough Engineer, Crossley Street, Halifax. Deposit, £2 2s.

Hemel Hempstead.—March 12. For the erection of eight cottages, for King's Langley Urban District Council. Mr. T. H. Lighbody, Architect, 20, Marlowes, Hemel Hempstead. Deposit, £1 1s.

Hinderwell.—March 12. For erection of 36 houses, for Hinderwell Urban District Council. Plans, etc., from Messrs. French and Wilkins, Architects, Flowergate, Whitby.

Brentford.—March 15. The Brentford Urban District Council invites tenders for the erection of 70 houses. Plans, etc., from Mr. W. J. W. Westlake, Borough Engineer and Surveyor, Clifden House, Boston Road, Brentford.

Southampton.—March 17. The Southampton Corporation invites tenders for the erection of 100 houses. Plans, etc., from the Borough Engineer, 123, High Street, Southampton.

Stockton-on-Tees.—March 17. For erection of 226 houses for Stockton-on-Tees Corporation. Plans, etc., from Housing Architect, 90, High Street, Stockton-on Tees. Deposit, £3 3s.

South Africa.—May 21. Tenders are invited by the Government of South Africa for the construction of one grain elevator (30,000 tons capacity), at Cape Town; one elevator (42,000 tons capacity), at Durban; and thirty-four smaller grain elevators in various districts, in connection with the South African Railways and Harbours. Full particulars from the High Commissioner for the Union of South Africa, 32, Victoria Street, London, S.W.1.

Bombay.—May 31.—The Corporation of Bombay invites tenders for the construction of about 105 miles of steel and reinforced concrete pipe lines, and contingent works. Forms of tender, etc., may be obtained from Messrs. Taylor & Sons, Consulting Engineers, 36, Victoria Street, Westminster, S.W.1.

PUBLICATIONS AND CATALOGUES RECEIVED.

B. S. P. Pocket Book.—This handy little pocket book, published by the British Steel Piling Co., contains a great deal of useful information for the engineer and contractor regarding steel sheet piling. In addition metric tables are given, and some notes and diagrams for the calculation of water pressure and bending moments on piling, and calculations for wallings and struts. A section is devoted to pile driving and particulars and illustrations are given regarding the plant supplied by this firm, which includes friction winches, pile hammers, pile shoes, concrete mixers, etc. Copies of this Pocket Book can be obtained from the British Steel Piling Company, Dock House, Billiter Street, E.C.

NEW COMPANIES REGISTERED.

Centrifugal Concrete Construction Syndicate, Ltd. (172,043). Registered December 16, 1920; 28, Cockspur Street, S.W. Manufacturers of pipes, bricks, tiles, pottery, concrete, and artificial stone. Nominal capital, £10,500 in 10,000 £1 shares, and 10,000 1s. shares. Directors to be appointed by subscribers; remuneration to be voted.

E. H. White & Co., Ltd. (172,283). Registered December 28, 1920. The Arches, Longwood, Huddersfield. Concrete and Concrete Block Manufacturers. Nominal capital, £2,000, in 2,000 £1 shares. Directors: W. H. Robinson, New Street, Milnsbridge, Huddersfield; W. E. Schofield, Thornfield, Milnsbridge; and H. W. Schofield, 14, Western Road, Cowlersley, Milnsbridge. Qualification of Directors, £50; remuneration to be voted.

Constone, Ltd. (172,515). Registered January 10. Manufacturers of artificial stone, reinforced concrete, etc. Nominal capital, £10,000 in 10,000 £1 shares. Directors: D. Cappella, 5, Evington Valley Road, Leicester; G. H. Cherry, 17, Bannerman Road, Leicester; W. Foulds, 422, Marlborough Road, Leicester; F. H. Jones, 340, Victoria Park Road, Leicester; F. Murby, 54, Nutfield Road, Leicester; and J. H. Wakefield, Huncote Road, Marlborough. Qualification of Directors, 500 shares; remuneration to be voted.

National Fireproofing Co., Ltd. (172,466). Registered January 6. Manufacturers of plaster slab machines. Nominal capital, £100,000 in 100,000 £1 shares. Directors: W. Collier, 60, Leigh Road, Leigh; J. Fogg, Alpine House, Pennington, Leigh; F. M. Johnson, "The Cottage," Beacon Hill, Newark; J. Livesey, 30, Swinley Road, Wigan; A. Young, Kilney Court, Worthington, near Wigan. Qualification of Directors, £2,500; remuneration £100 each (Chairman, £125).

South of England Concrete Moulding Co., Ltd. (172,676). Registered January 24. Cement slab manufacturers. Nominal capital, £8,500 in 8,500 £1 shares. Directors: W. H. Wroth, Horsebridge Farm, Kingsomborne, Hants; P. E. S. Parker, Oakleigh, Lakewood Road, Chandler's Ford, Hants; and J. T. Matthews, St. Michel's Chambers, Southampton. Qualification of Directors, £100; remuneration, £50 each (Chairman £100).

Bloxham and Scuffells, Ltd. (172,902). 70a, Basinghall Street, E.C.3. Registered February 1. Steel and ferro-concrete constructors and builders. Nominal capital, £2,500 in 1,000 £1 preference shares, 1,484 £1 ordinary shares, and 16 £1 founders' shares. Directors: C. A. Bloxham, C. C. Baker, and R. O. Grant. Qualification of Directors, £100; remuneration, £50.

Stronghold Cement Block Construction and Machine Co., Ltd. (172,941). 34–35, Norfolk Street, Strand, W.C.2. Registered February 2. To acquire patents and inventions for improved methods of erecting portable concrete buildings, and to manufacture cement blocks, etc. Nominal capital, £10,000 in 20 £20 preference shares, 899 £10 ordinary shares, and 10 £1 ordinary shares. Directors: A. Lusty, P. A. Smith, and E. J. Ward. Qualification of Directors, 10 shares; remuneration to be voted by Company.

RECENT PATENT APPLICATIONS.

112,449.—W. C. Davis : Reinforced concrete walls.
132,270 and 132,272.—Steven's Partition and Floor Deadener Co. : Floor construction.
139,209.—Bonnett et Fils : Moulds for concrete blocks.
143,229.—H. E. Brown : Concrete wall construction.
145,547.—T. Moser : Method of spraying mortar or concrete.
153,991.—W. Marriott : Concrete reinforcement.
154,051.—N. A. M. McDowell : Concrete block-making machine.
154,090.—A. M. Cramer : Hollow building blocks.
154,091.—J. D. Roots : Slab wall construction.
154,096.—Concrete Dwellings, Ltd., and H. Eldon-Brown : Pre-cast concrete moulds.
154,236.—K. Friedrich : Glazing cement and other building materials.
154,327.—R. Lowry : Concrete cavity walls.
154,379.—F. Walker : Building blocks.
154,392.—M. M. Smith : Wall construction
154,461.—G. H. Forrester : Concrete walls.
154,484.—W. Muirhead : Concrete shoes for piles.
154,510.—F. W. Bakema : Furnaces for cement manufacture.
154,520.—P. C. Cannon : Moulds for concrete blocks, pipes, posts, etc.
154,759.—T. A. & J. L. G. Aldridge : Building blocks and slabs.
154,780.—C. E. Masters : Manufacture of building blocks.
154,811.—H. D. & C. H. Henderson : Moulds for making concrete blocks.
155,043.—A. E. Marshall : Concrete floors.
155,072.—C. McDowall : Fireproof floors.
155,075.—R. C. Littlejohns : Concrete block mould.
155,120.—J. Thewlis : Cavity concrete walls.
155,127.—J. Ryan : Method of fixing building blocks.
155,326.—H. E. Gerard & L. G. Mouchel & Partners : Reinforced concrete construction.
155,385.—W. E. Clifton & J. S. Ewart : Concrete floors and roofs.
155,431.—H. D. Baylor : Manufacture of slow-setting, fat and waterproof cement.
155,454.—F. Malgarini : Reinforced hollow blocks.
155,599.—C. Rabut : Means of camping together component wall parts.
156,819.—G. H. Forrester, G. Marsh and J. D. Marsh : Concrete building construction.
156,882.—F. A. Noullett : Building blocks.
156,933.—J. R. Matthew and G. R. Bowers : Concrete slab or block buildings.
156,934.—R. E. Matthews and J. R. Bowers : Method of erecting concrete-slab or block buildings.
156,973.—F. C. C. Rings : Reinforced concrete floors
156,275.—J. Claughton : Concrete houses.
156,319.—D. de Nagy : Building blocks.
156,385.—W. Turner : Concrete sewers and tubes.
156,442.—H. J. C. Forrester : Insulating building material.

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CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

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EDITORIAL NOTES.

AMERICAN METHODS.

INTRODUCTION.

The execution of concrete work in all countries where modern methods are known must necessarily follow on similar lines, but the cost, speed and quality of the work may be considerably affected by the manner in which the methods are applied, and for this reason some benefit may be obtained by a comparison between the general principles which govern the execution in any two countries.

Mass production has always been a strong feature in American industry, and a study of the methods employed in the building trade, and in concrete work in particular, reveals the fact that the Americans have a natural aptitude for organising and executing large schemes in the minimum possible time. We do not wish to imply that this natural aptitude is confined to the Americans alone, but it is certainly more in evidence ; and this fact may be due to the industrial developments which provide more opportunity to the engineer and contractor, but certainly full advantage is taken of such opportunity. Generally speaking, however, in this country there is a strong conservative tendency and development is hampered instead of being encouraged by those who could do much in the cause of progression. An illustration of this can be found by a comparison of the research work carried out in the United States and this country in connection with all classes of concrete work, and again in the adoption of the mushroom or flat slab system in the former country and its prohibition here.

In connection with speed there is a general impression that everything is quick in the United States, but a careful analysis will indicate that this impression is incorrect, as in many respects the speed does not exist, and there is a curious inconsistency between the wonderful speed that is achieved in large projects where pressure is applied and the many ordinary services in the daily routine where no pressure is applied and things are extremely slow. Many instances could be given to illustrate this statement, but they do not come within the scope of these notes, and the inconsistency is mentioned merely to show the effect of efficient organisation and its application to building work.

ORGANISATION.

Considerable time and thought are expended on the question of organisation in American contracts, and the whole scheme is laid out before any work is commenced. Generally speaking, the American contractor appears to be slow in making a commencement of the work on the site itself, but in reality he is busy planning and deciding on the chief features of the plant lay-out, the flow of materials and the main points to be considered before any actual work of erection is started, and in this respect time and money are saved when the work is in hand.

Various sketch plans are prepared to give alternative schemes for the location of concrete mixers, industrial and standard gauge tracks, storage yards, shops and mills generally, and the sequence of execution is carefully considered. These sketch plans are then discussed from various standpoints, and a final plan is prepared which provides a definite location for all stationary equipment, stores and temporary offices, together with the track runs that will be necessary, temporary water and power lines, and all the items required during the construction period.

The arrangements, being carefully determined by a good organiser in the first instance, are only varied to suit any exceptional circumstances that may arise during the course of the work, and a definite method of this nature enables the construction to be carried out uninterruptedly with the minimum of labour and cost.

The same principle is followed, of course, by many large contractors in this country, but not in such a thorough manner, and continual re-arrangements and modifications are often necessary, owing to the casual consideration given to extremely important points in the first instance.

In concrete work the initial lay-out is probably more important than in any other trade, because the sequence of operations must be planned to avoid passing over work newly executed, and the flow of the raw materials to the point of mixing and the methods of handling the mixed concrete will have considerable effect on the cost of the work.

THE USE OF PLANT.

The most striking feature of American concrete work is the extensive use of plant of every description, and it is this factor which is mainly responsible for the speed so often achieved. Every machine which can profitably be employed is provided as a matter of course, and a bold policy is pursued in providing equipment on a large scale, which reduces labour to a minimum and increases output to the maximum. On work of any magnitude one or more stationary concreting plants are installed with derrick, hoppers for storage, hoisting towers, chutes and elevators complete, and the output from a well-designed plant is considerable. A convenient point is selected for the installation and, if possible, a standard gauge track is carried right up to the plant to facilitate the unloading of raw materials. Cement storage sheds are built adjoining the track to allow this material to be unloaded and handled directly into the shed, and sloping runways or belt conveyers are provided to give a direct supply of cement to the gauging hopper over the concrete mixer. Immediately over the mixer large bins constructed of heavy timbers are erected for the storage of fine or coarse aggregate with hopper bottoms discharging directly into the gauging hopper of the mixer. A derrick is installed adjacent to the tracks, and by means of a grab bucket the aggregate is unloaded from the railway cars directly into the storage bins in a quick and economical manner.

The discharge from the mixer—(usually of the maximum capacity)—is made directly into a bucket elevator which raises the mixed concrete to the desired height on the tower where it is tripped to discharge into the chutes and thus flow by gravity to the point required. With a well-designed plant of this kind, the output is frequently as much as one cubic yard per minute, which means 480 yards cube in a working day of eight hours. Objection to spouting concrete by means of towers and chutes has been raised by many engineers in this country owing to the separation of the coarse aggregate during the gravity flow, but in all important work the mixed concrete is not spouted directly into position, but is discharged into a large receiving hopper where the whole of the material comes together again, and from this hopper it is measured out into light concrete buggies and transported by hand to the point where it is actually placed. The buggies are light metal receivers carried on two wheels which are easily handled and much preferable to the ordinary type of wheelbarrow so often employed. In transporting the concrete care is exercised to provide light runways which permit of a continuous flow of buggy pushers from the hopper to the place of deposit in such a manner that a complete circuit is made and no time is lost by waiting. It is a common sight in many concreting operations to see a line of men held up at some point owing to the necessity of allowing a string of returning empties to cross a narrow gangway to reach the loading point, with a consequent cessation of work both at the place of deposit and the point of loading. When a central concreting plant is required to mix material for some work too far removed to allow of spouting and hand wheeling, the mixture is discharged into a suitable hopper at any convenient spot for the purpose of feeding into special hopper cars which are transported over ordinary narrow-gauge track to the required situation. These cars have hopper gates which open to discharge the concrete at the side, either into wooden chutes or buggies, according to circumstances. These trains are commonly called "soup trains" in America, and some very quick work can be accomplished by their use. In some cases when towers are not applicable a standard-gauge track is laid alongside the work and a train is made up consisting of cars of aggregate and cement attached to a flat-bottomed car, on which a concrete mixer with petrol-driven engine is attached, and this can operate up and down the length of the work as required, while additional supplies of raw materials can be brought to the mixer with the minimum amount of handling.

By these and similar methods concrete work is being economically and quickly executed in America, and a very progressive spirit is shown by the manner in which the fullest advantage is taken of any equipment suitable for the work in hand. The same spirit is shown in all the other work in the building industry, as extensive use is made of steam-shovels, trench-diggers, ploughs, scrapers, derricks, compressed-air plants, locomotive cranes and hoisting appliances of all kinds.

A conscientious study of many of the appliances used in America by the engineers and contractors of this country would lead to a more extensive adoption here with a consequent saving in time and money, more especially on schemes of any magnitude.

FORMWORK.

Every advantage appears to be taken of standardisation of forms, and wherever possible sections easily erected and dismantled for re-use are employed to reduce the carpenter's work on the actual structure to the minimum.

Timber is plentiful and there is, in consequence, a natural tendency to extravagance in the use and waste of this material, but, as a general rule, the American carpenter is very expert in the speedy erection of plain carpentry work of the kind required in the forms for concreting.

Extensive use is made of concrete distance pieces and universal clamps, which facilitate easy removal, and a well-designed form is usually adopted. In the case of the " flat slab " type of building which is so extensively used steel forms are always used for the interior columns and their caps, and these can be hired on terms which are advantageous as compared with the cost of making special forms for any one scheme.

REINFORCEMENT.

Wherever possible advantage is taken of reinforcement made up previous to placing in position and the rods are wired together to ensure easy handling, while plain and deformed bars are used impartially.

Careful supervision is invariably required in the placing of the steel, and also to see that it is not displaced during the concreting operations, as there appears to be a general tendency to carelessness both in the workmen and foreman which is aggravated by the speed usually maintained. Inserts for the attachment of pipe-hangers and other fittings are extensively used, these being placed on the formwork and kept in position by nailing to prevent displacement during concreting, these inserts being obtainable in many different types and ensuring easy and satisfactory attachment.

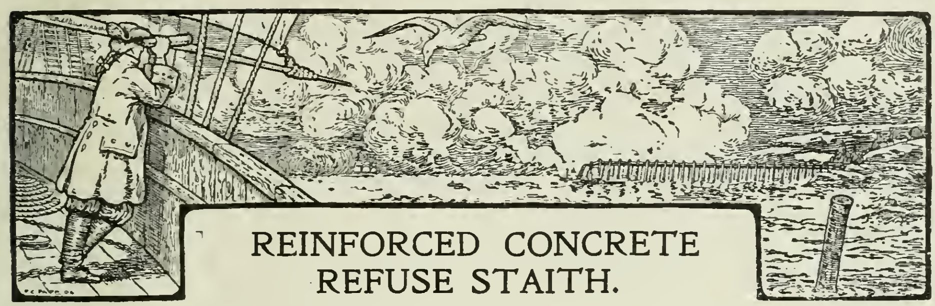
In American practice there is a marked tendency to use small diameter rods in large numbers in preference to fewer and larger rods, but in many instances this appears to be carried to excess, thus making the reinforcement unnecessarily complicated and difficult in execution.

CONCLUSION.

The speed which is maintained renders it necessary to provide several methods of protecting the work already executed, and as the floors on a building are often finished by treating the surface of the structural concrete immediately with neat cement and floating to give a finished surface on which it is necessary for workmen to work at the earliest moment, extensive use is made of sawdust with very good results.

In many cases black labour is employed on concrete work, and satisfactory work is obtained if good supervision is provided, while the organising of the scheme to produce competition between different gangs is a big factor in the speed.

Generally, a study of American methods of executing concrete discloses two main factors as contributing to quick and economical work, viz., good organisation and the extensive use of plant and equipment of all kinds. The quality is fairly well maintained as a general rule, and we feel that it would be of advantage to the industry in this country if more use was made of several good ideas which are so frequently applied in America.



REINFORCED CONCRETE REFUSE STAITH.

CONSTRUCTED FOR THE GATESHEAD CORPORATION.

In common with all the great seaports, and many smaller ports and harbours of the British Isles, Newcastle-on-Tyne, Gateshead and other towns in the district known as Tyneside possess numerous examples of reinforced-concrete construction, some dating back twenty years or more, and others recently completed or in course of execution.

One of the latest reinforced-concrete works commenced on the Tyne is the staith, or wharf, described below. The method of dealing with town refuse for which the staith was built, had previously been adopted by the City of London Corporation, for whom a reinforced-concrete jetty was built on the Thames in 1905. Although employed for a similar purpose, the jetty does not embody the more recent and ingenious structural and mechanical devices for the convenient handling of refuse which form part of the Gateshead staith.

In the year 1911 the Corporation of Gateshead on the recommendation of the Borough Engineer, Mr. N. Percy Pattinson, decided upon the construction of a staith and overhead gantry for the disposal of town refuse by loading it into barges or lighters, such vessels being afterwards towed down the River Tyne and discharged in the North Sea.

The site chosen for the erection of the new staith is on the south bank of the river near the North-Eastern Railway Goods Depot and Locomotive Works immediately above the renowned High Level Bridge of Robert Stephenson.

In pursuance of their project, the Corporation in the year stated issued invitations to four firms of structural engineers to submit designs, specifications and accompanying estimates of cost. These were received in due course and early in the year 1912 were submitted by the Corporation to Messrs. D. Balfour & Son, civil engineers of Newcastle-on-Tyne and London, for investigation and advice as to the relative merits of the four schemes put forward.

Having gone fully into the drawings, checked the stresses involved and considered the provisions made for resistance to the latter, Messrs. Balfour & Son came to the conclusion that the scheme prepared by Messrs. L. G. Mouchel & Partners, Limited, of Westminster and Newcastle-on-Tyne, was calculated most efficiently and economically to comply with the requirements of the case.

Consequently this scheme, embodying the application of Mouchel-Hennebique reinforced-concrete construction, was recommended to and subsequently adopted by the Corporation of Gateshead.

Before the proposed work could be taken in hand, it was necessary to obtain

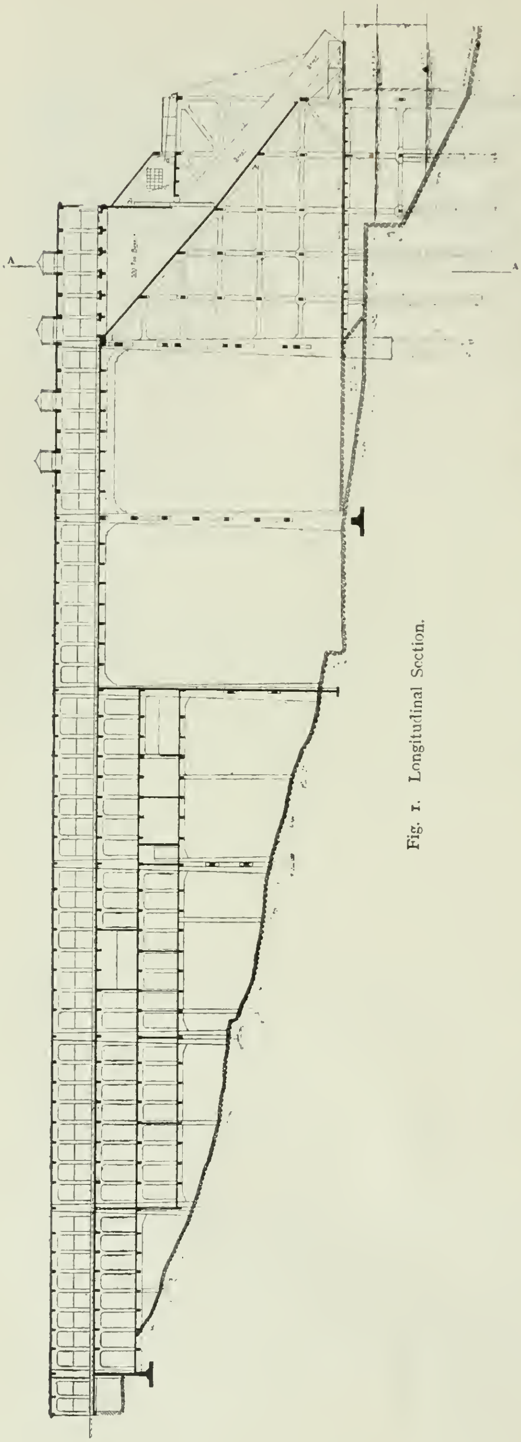
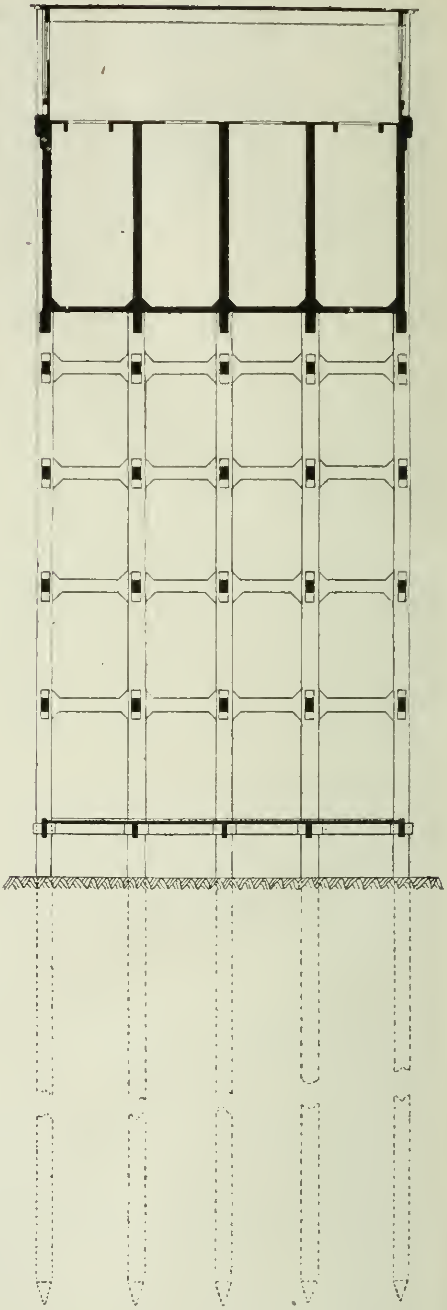


Fig. 1. Longitudinal Section.



CROSS SECTION AA.

Fig. 1A.

Reinforced Concrete Refuse Staith, Gateshead.

the sanction of the Local Government Board as a preliminary to the issue of a loan in respect of the cost of construction. Fully detailed working drawings, together with the calculated moments and stresses were then prepared and submitted to the Local Government Board, by whom a local inquiry was held in 1914, when the scheme was fully gone into and explained by Messrs. D. Balfour & Son, the civil engineers acting on behalf of the Corporation.

After receiving the report of their Engineering Inspector, the Board sanctioned the scheme and granted a loan repayable in twenty-two years. Although this sanction was given in 1914, the outbreak of war was responsible for the deferring of construction until last year, when a start was made by the contractors, Messrs. Brims & Co., of Newcastle-on-Tyne and London. The resident Engineer was Mr. R. G. Huck, of Heaton.

Figs. 1 and 1*a* include longitudinal and cross sections of the staith and overhead gantry in accordance with the complete project, only part of which is now being carried into execution.

Commencing at the river end, the staith projects 36 ft. beyond the bank and is 38 ft. in width. This portion is founded on reinforced-concrete piles and cylinder piers, strongly braced and covered by decking which extends back 76 ft. from the river front, the back part of the decking being supported by reinforced-concrete piles and rectangular piers founded on similar piles. The staith and the foundation behind it carry the river end of the gantry, which includes a range of four triangular bunkers, each 33 ft. high by 36 ft. from front to back at the top by 8 ft. wide inside, as well as tipping platforms and the necessary mechanical equipment for the delivery of refuse into light craft.

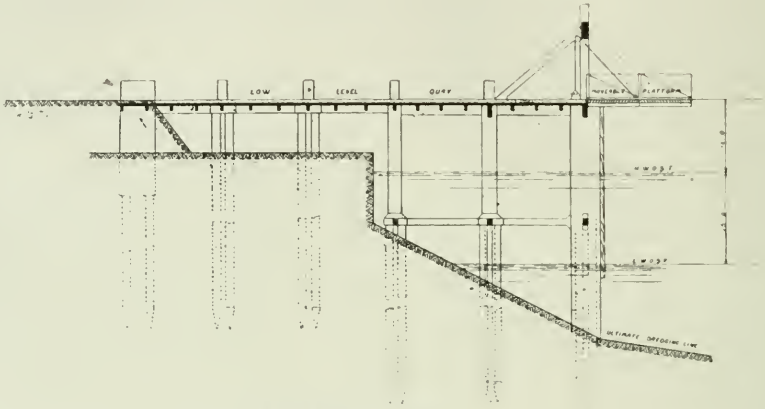
Refuse will be brought to the bunkers along a gallery 357 ft. in length by 37 ft. in width inside, the landward end of the gallery starting from the top of the river bank which is 78 ft. above the level of the ground along the river front. The gallery is 12 ft. high from floor to flat roofing, the latter being supported by columns spaced 6 ft. apart, centre to centre. The triangular framed structure carrying the refuse bunkers and the river end of the upper gallery, is formed of columns and horizontal bracing members, the rigidity of the connections being aided by knee braces of ample proportions. The construction at the extreme end enclosing the refuse shoots is of similar character.

The landward end of the main triangular framework includes a pair of rectangular piers, 99 ft. in height from base to top and tapering from 6 ft. 3 in. to 3 ft. in diameter. These piers are founded on reinforced-concrete piles which project into the interior of the pier at the lower end. The piers thus firmly rooted into the ground form a solid and substantial abutment for the bridge shown in the drawing, at the same time affording vertical support for the inner face of the triangular frame.

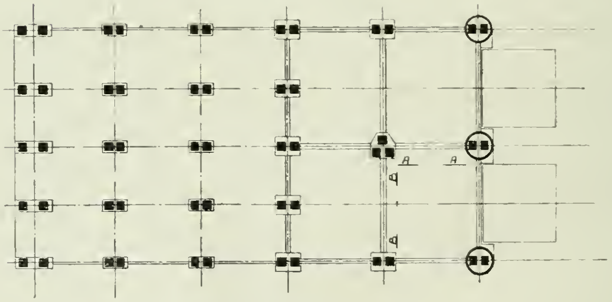
The piers are braced together near the bottom by members entering into the construction of the staith decking, at the top by the transverse floor and roof beams, and at four intermediate levels by special bracings as shown.

The framework contributed very effectively to the lateral rigidity of the superstructure, which, owing to its great height, obviously needs most adequate wind bracing, especially during the easterly gales sweeping up the valley of the Tyne in the equinoxes.

Along the lower bank of the river runs a roadway, across which passes the upper gallery, constituting a bridge with two 50 ft. continuous girder spans. The landward abutment is provided by a pair of tapering piers 84 ft. in total height and a third pair of piers, 91 ft. high, form an intermediate support. These piers strongly braced transversely are of generally similar construction to that of the pair first described, save in the respects that they are built up from extended footings instead of being founded upon piles, and that the landward abutment has the spaces filled in with a vertical slab of ferro-concrete with stiffening ribs, the whole in monolithic connection, and converting the abutment into a retaining wall capable of holding up any filling material deposited behind it, while at the same time the vertical slab acts as an end wall to the two lower storeys of galleries at the landward end of the gantry.



LONGITUDINAL SECTION.



PLAN OF LOWER WHARF.

Fig. 2.
Reinforced Concrete Refuse Staith, Gateshead.

The lower galleries, divided up into chambers of various sizes as represented in *Fig.* 1, are 204 ft. and 154 ft. long respectively, one starting 12 ft. from the top edge of the river bank and the other commencing at a distance of 61 ft. from the same line. They will be utilised as stables, cartsheds and garage for motor wagons belonging to the Corporation. The construction is very much like that of the topmost gallery and the three storeys are supported by seven pairs of columns and four pairs of tapering piers, all rising from extended footings. Access will be given to the various galleries by means of inclined gangways.

Let us now turn to the structural details of the new staith, the first section of the work represented in its finally complete form by *Fig.* 2.

Briefly described the staith comprises a reinforced-concrete platform, 75 ft. from front to back by 38 ft. wide carried on fifty-three Hennebique reinforced-concrete piles, 16 in. square in cross section driven for the most part in pairs to an average depth of 24 ft. below water level, and providing for the river bed immediately in front to be dredged to a depth of 12 ft. below L.W.O.S.T.

Fig. 2 includes a longitudinal section and a plan of the staith below the decking. Each pair of piles in the front row is enclosed by a reinforced-concrete cylinder, 4 ft. 6 in. in diameter, the shell being made of precast sections 4 in. in thickness. After the sections have been lowered into position one after another until the pier has been built up to the predetermined height, they are jointed together with cement grout and the interior is filled in with concrete suitably reinforced so as to form a solid pier.

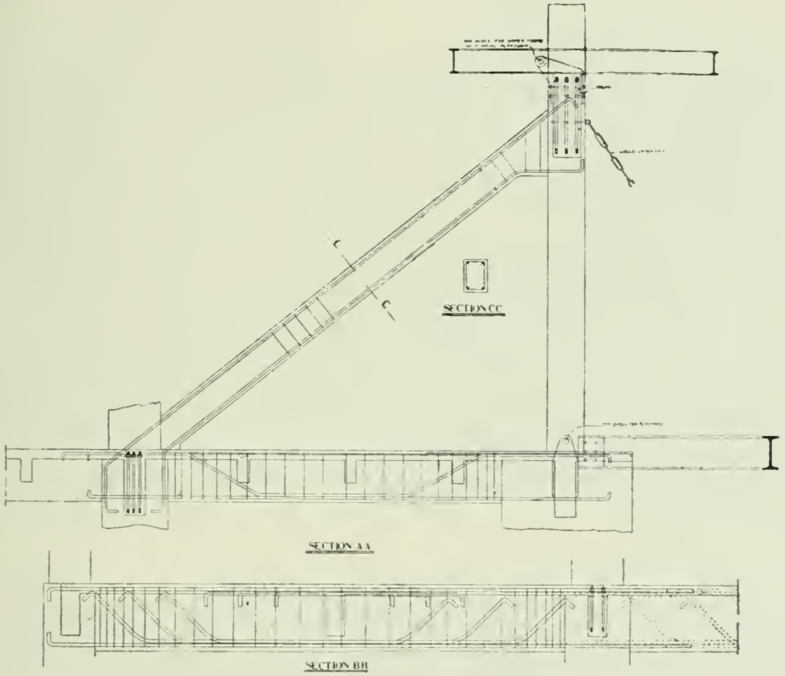


Fig. 3. Details of Typical Main Beam.
Reinforced Concrete Refuse Staith, Gateshead.

Piers of the type in question are of much value along the front of a wharf or jetty because of their great strength and rigidity, and can therefore be spaced far wider apart than reinforced-concrete or other piles. Moreover, they can be, and in many instances have been employed without bracing members intermediate between the bed of the sea or river and the beams connecting the piers

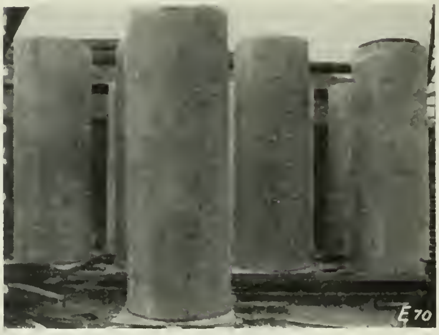


Fig. 4. Showing Cylinders.

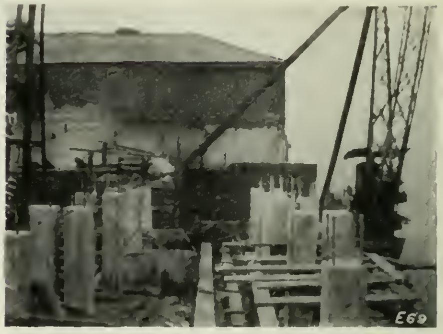


Fig. 5. Showing Land Piles Stripped for Beam and Decking Connections.

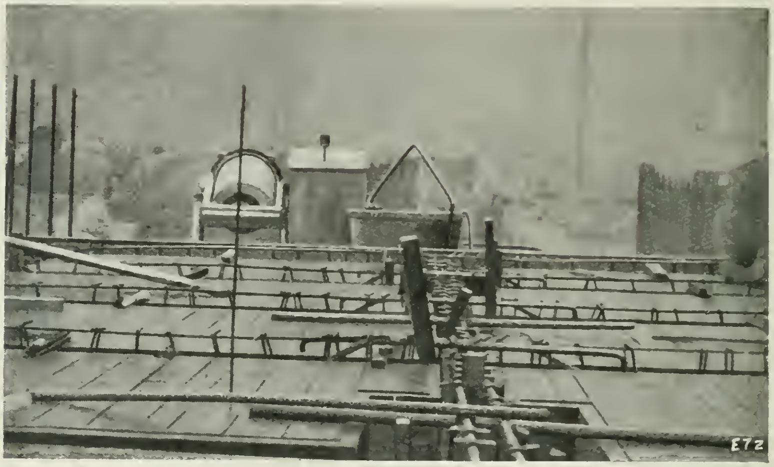


Fig. 6. Showing Beam Steel in Position.

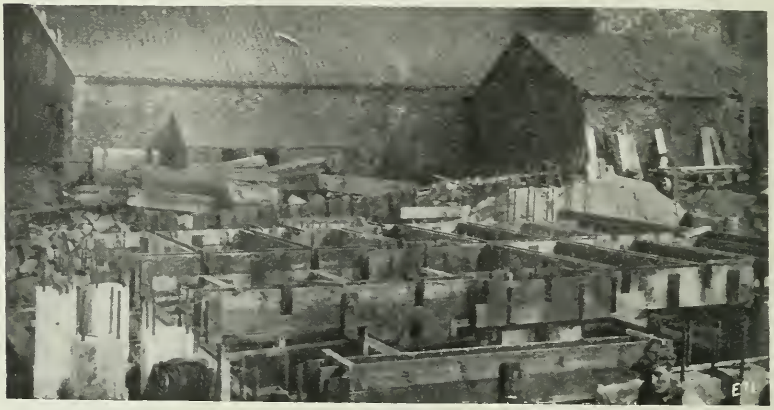


Fig. 7. Showing Decking.
REINFORCED CONCRETE REFUSE STAITH, GATESHEAD.

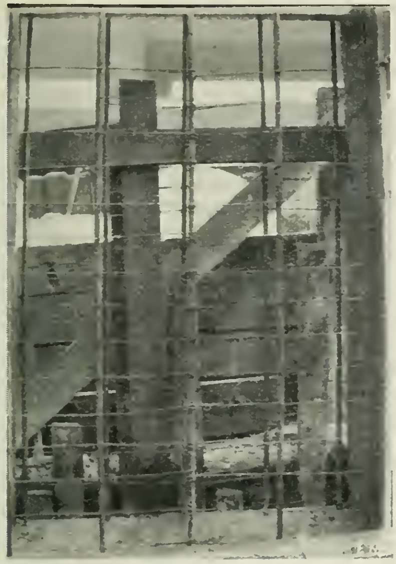


Fig. 8. Showing fixed Steelwork above ground level in Column A.

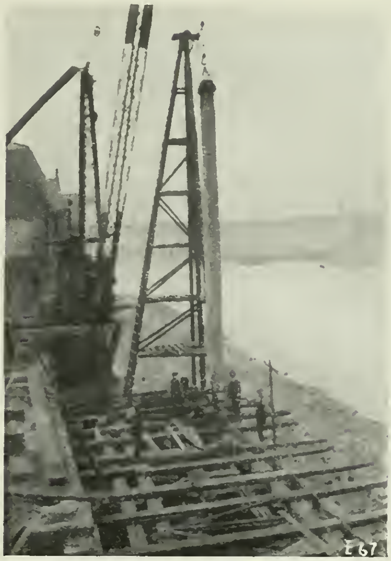


Fig. 9. Pitching Pile.

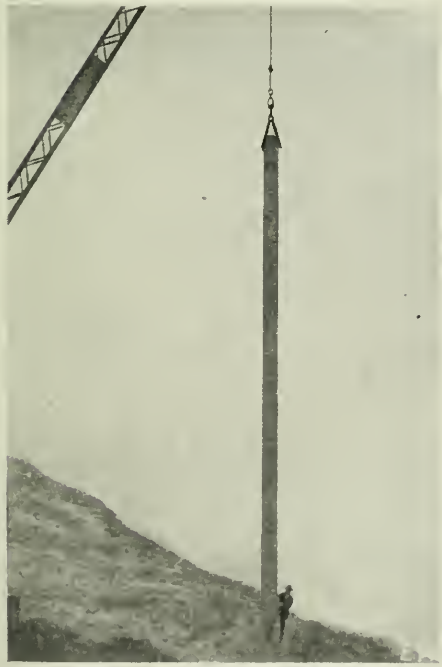


Fig. 10. Showing Pitching of Pile.

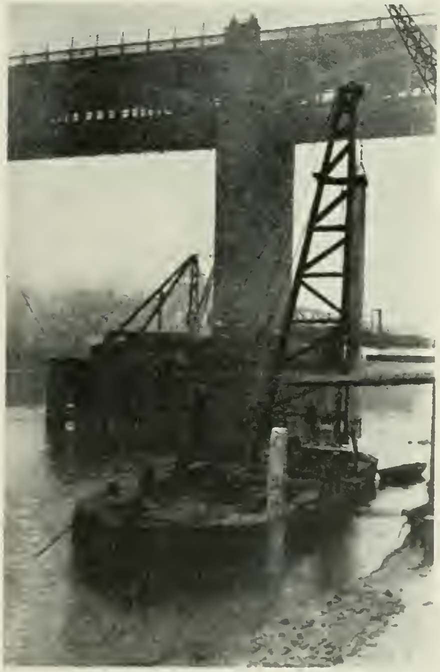


Fig. 11. Showing Pitching of Pile.

Reinforced Concrete Refuse Staith, Gateshead.

at top. Thus this type of pier obviates the difficulty in the way of bracing ordinary piles in subaqueous work.

One of the first things done by Messrs. Brims & Co. in commencing operations was to establish a yard near the site of the staith for moulding and seasoning piles and cylinder sections. The cylinder sections are 13 ft. long each by 4 ft. 6 in. in diameter. The piles were slung by the aid of a derrick crane to the positions where they were driven, as illustrated by *Figs.* 9, 10, 11. Measuring 48 ft. in length by 16 in. square and weighing about 5 tons each, the piles were slung and pitched as shown by the illustrations, in the second of which one of the piles may be seen close to the pile-driving machine.

When the piles had been driven to refusal, they were trimmed off to uniform level at the top and the concrete was stripped away so as to allow the reinforcing bars to be incorporated with the caps formed for connection with the bracing members below high water level, those in the front row being enclosed by the cylinder sections. The two front rows of piles on the landward side were incorporated with the beams of the decking, and those in the back row of all were incorporated in the columns to be extended later to the top of the overhead gantry. It may here be said that the piers, piles and columns have been designed of sufficient strength to carry the lofty superstructure to be erected hereafter, and that special provision has been made at the head of each column for the satisfactory connection of the new and old work.

Fig. 3 gives details of a typical main beam, and part of the provision made for carrying the platforms to be employed in tipping refuse into vessels alongside the new staith.

BRIDGE OVER THE MACQUARIE RIVER, NEW SOUTH WALES.

After a life of fifty years the timber bridge over Macquarie River, New South Wales, has been replaced by the structure illustrated in our Frontispiece.

The structure consists of two steel truss spans each of 120 ft. centres of bearings and eleven reinforced concrete approach spans on reinforced concrete piers and abutments. The roadway for vehicular traffic is 20 ft. between kerbs and is of reinforced concrete with a cantilever footway 5 ft. wide.

The piers consist of two reinforced concrete shafts braced at intervals by webs about 10 ft. deep by 18 in. thick for the main piers and 12 in. for the piers under the approach spans. The shafts are octagonal in section, of varying dimensions and are stepped from top to bottom to square bases which are supported by timber piles driven into the bed of the river.

The shaft of the centre pier under the two steel spans is 5 ft. by 5 ft. outside increasing to 6 ft. by 6 ft. just above the base, which is 10 ft. by 15 ft. by 5 ft. thick, the two bases being connected with a web 2 ft. 6 in. wide the full depth of the footings. The specification provided for the concrete being laid in the dry, and steel sheet piling was driven 20 ft. into the gravel of the river bed. The pumps could however only lower the level of the water one foot and eventually the bottom was sealed by depositing concrete 2 ft. thick over the bottom of the excavation and building a timber coffer-dam inside the steel piling. This allowed the remainder of the work being completed in the dry.

(*Continued on page* 265.)

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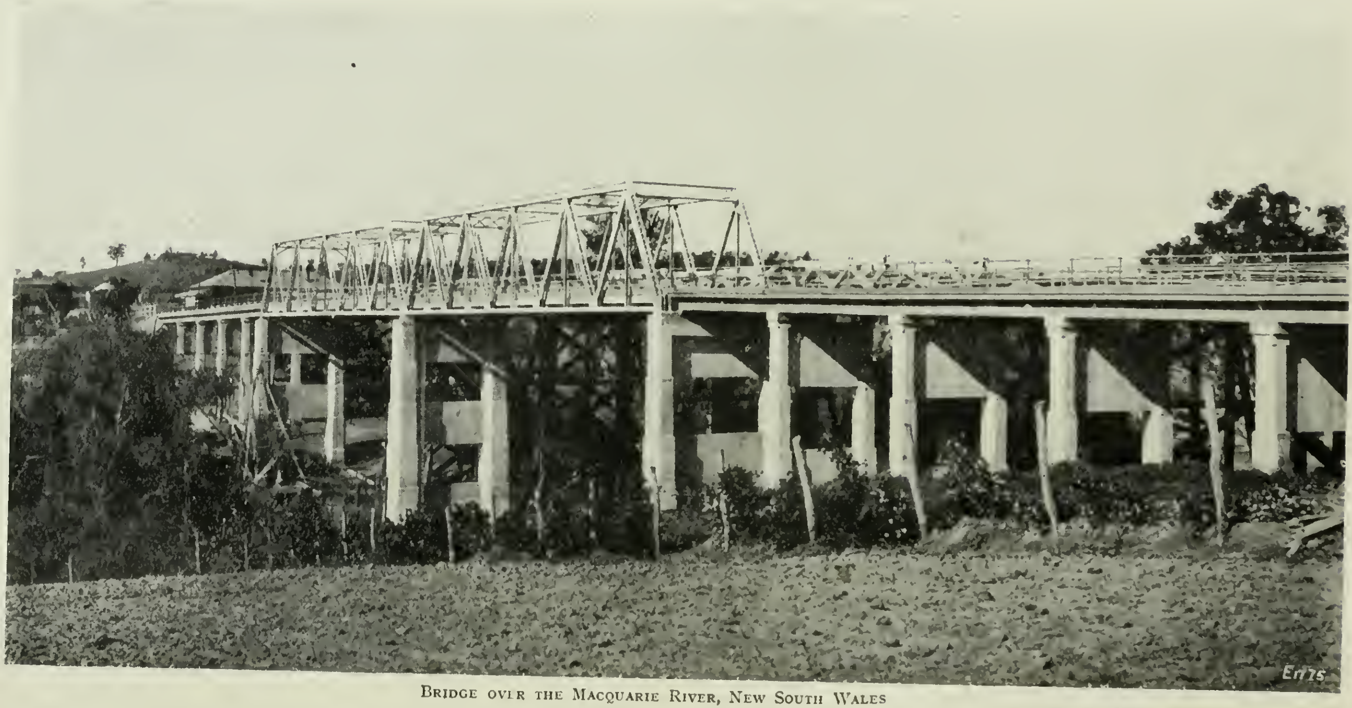

BRIDGE OVER THE MACQUARIE RIVER, NEW SOUTH WALES
(*For description see page* 222.)

PORTLAND CEMENT.

ITS TESTING AND SPECIFICATION—BRITISH AND FOREIGN METHODS.

By R. E. STRADLING, M.C., B.Sc., A.M.I.C.E., A.M. Am. Soc. C.E. (Lecturer in Civil Engineering University of Birmingham).

The first part of this article appeared in our March Number, page 169.—Ed.

TABLE VII.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

STRENGTH TESTS (*contd.*).

C. Compression Tests. (Neat Cement.)

British.	Not used.
U.S.A.	Not used.
French.	Not used.
German.	Not used.

D. Compression Tests. (Cement and Sand.)

British.	Not used.
U.S.A.	Not used.
French.	Not used.
German.	1 to 3 standard quartz sand. All sand is tested by Royal Institute of Testing Materials, and supplied through the Cement Manufacturers' Laboratory, Karshorst, in sealed bags. Passes 1·35 mm. (·0533″) mesh and retained on ·775 mm. (0·0305) mesh. 850–860 gms. of mortar filled in cube moulds (50 sq. cm. side) by Böehme hammer (150 blows) 24 hrs. in moist air. After 7 days old at least 120 kilo/cm^2 (≏ 1720 lb/□″) ,, 28 ,, ,, ,, ,, 250 ,, ,, (≏ 3570 lb/□″)

The points to be noted about the German specifications for this test are :—

(1) Standard sand prepared at one place and tested there ; then sold in sealed packets.

(2) Mechanical mixing.

(3) Mechanical ramming.

This test appears to the writer to be as free from the personal equation as it is possible at present to make it.

With regard to compression tests in general ; the real troubles with them are :—

(1) Difficulty of getting central loading.

(2) Variation of strength with the kind of material through which the load is applied to the specimen (e.g. lead sheet, steel, felt).

(3) Difficulty of knowing what kind of stress is actually being measured.

Fig. 14 shows fracture of cement blocks.

It will be seen the cube has fractured along what are roughly diagonal planes. There are two possible explanations of this :—

(1) Shear failure (maximum shear planes).

(2) Tension failure at right angles to direction of loading.

If the former is the cause of failure, fairly consistent results might be expected.

If the latter, every difference in the surfaces (cement block and plate of testing machine) will cause this to vary, as the strength is probably a function of the coefficient of friction between them as well as other variables.

It appears to the writer that the most suitable test for ordinary work is the tensile test—cement and sand.

The factors affecting the strength are shown in *Figs.* 15 to 19.

***Fig.* 15. Variation with water content.
***Fig.* 16. Time of mixing.
***Fig.* 17. Temperature of materials.
†*Fig.* 18. History of Specimen.
†*Fig.* 19. History of Specimen.

These curves show the great importance of :—

(1) Fixing the proportion of water to be used.
(2) Keeping conditions of mixing content.
(3) Keeping conditions of storage content.

The chief difficulty is, of course, the first—the amount of water. The British specification makes but little attempt to help in this subject.

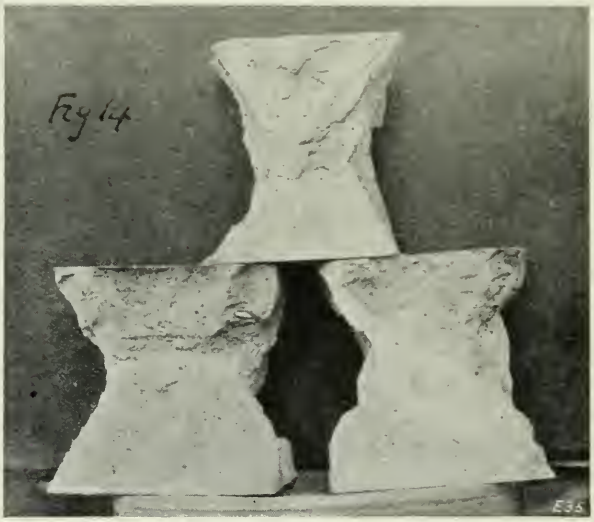

Fig. 14.

France and U.S.A. do specify, as has been seen, the methods of obtaining a consistent proportion of water.

Germany has the most elaborate method and I suggest probably the most accurate.

Setting Time.

As stated at the beginning of this paper the setting of a cement is a chemical action taking place over a short or long period according to the sample of cement. When any chemical action takes place, some thermal change practically always accompanies it.

Taking advantage of this fact, the progress of chemical action in a setting cement can be watched by means of registering temperature changes. A series of experiments in this was carried out by M. Gary and I reproduce three of his diagrams in *Figs.* 20, 21, and 23.‡

Under suitable conditions these thermal methods give a far better guide to the

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* Plotted from data of Steinbruck, given in *Desch-Chemistry and Testing of Cement.*

† From Faber and Bowie, *R.C. Design*, Vol. 1.

‡ From *Concrete and Constructional Engineering*, 1901-1907, Vol. 1, pp: 356, 432-3.

"setting time" than the arbitrary mechanical tests of the "*Vicat Needle.*"

In *Figs.* 20 and 21 the Initial and Final sets as registered by the Vicat needle are marked I and F respectively. It will be seen that the chemical action causing a rise in temperature is starting before the initial set as registered by the Vicat needle method.

Again, although in *Fig.* 20 the Final set as registered by Thermal method and Vicat needle are practically identical, in *Fig.* 21 the Final set registered by the Vicat needle occurs at about 10·9 hours after mixing, but the real temperature rise of magnitude in this cement occurred at about 18·3 hours after mixing.

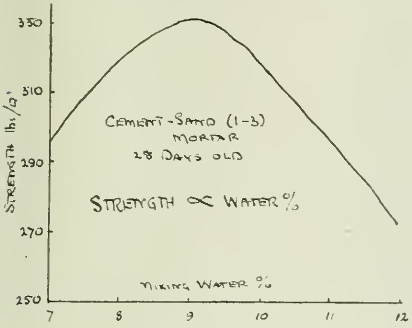


FIG. 15.

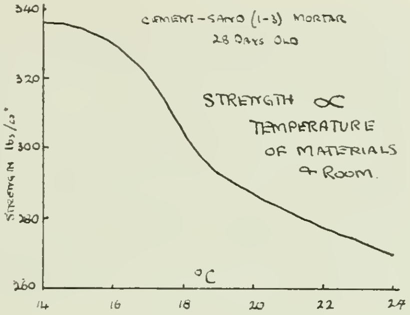


FIG. 17.

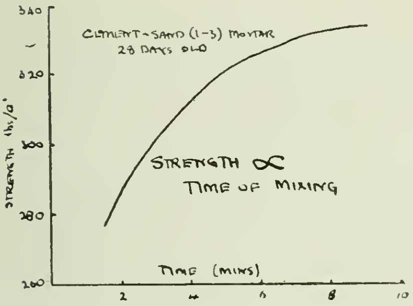
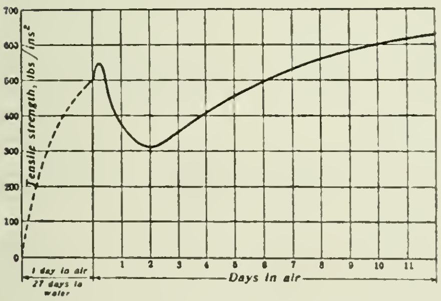


FIG. 16.

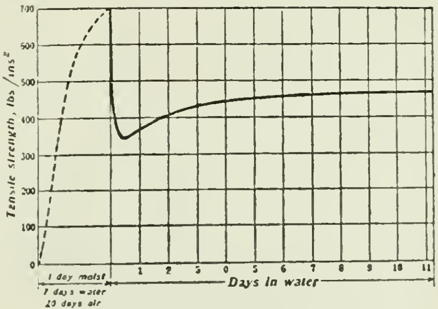
STEINBRÜCK (1901)

plotted from data
given by Desch (Chem. & Testg of Cement)



—Curve showing effect of drying a specimen of concrete previously immersed

FIG. 18.



Curve showing effect of immersing a specimen of concrete previously dry.

FIG. 19.

It would seem to be a dangerous proceeding to disturb this cement for some considerable time after mixing, if this comparatively violent chemical action is going on.

In general the lowest point in the curve indicates approximately the initial set as registered by the Vicat needle and the highest point, the final set—though this latter does not always correspond. As already stated in one case given the " peak " on the temperature curve occurred about eight hours after the final set as registered by the Vicat needle. This kind of thing might certainly be dangerous in practice.

Table VIII. gives a comparison of the various methods used.

As will be seen the Vicat needle is used in all cases.

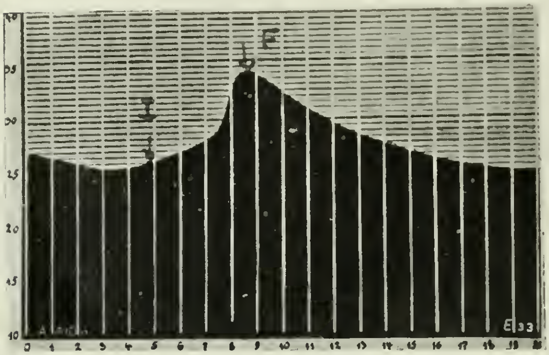


FIG. 20. PROF. GARY'S CURVES OF TEMPERATURE RISE AS SETTING OF CEMENT.

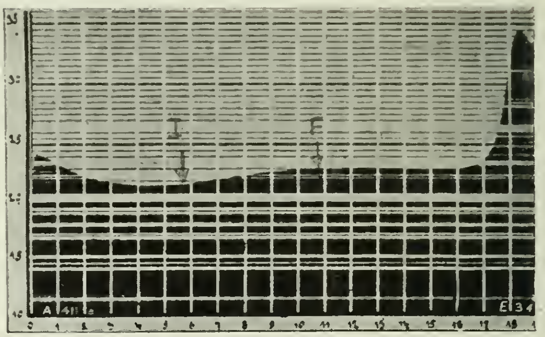


FIG. 21. AS FIG. 20, ANOTHER SAMPLE.

TABLE VIII.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

SETTING TIME.

British. Vicat needle with special needle for final set.
Initial—Not less than 20 minutes. Needle just fails to pierce whole block completely.
Final—Not more than 10 hours. Special needle point just marks, ring does not.
If specially quick setting cement is required initial not less than 2 mins. final 30 mins.

U.S.A. Vicat or Gillmore needles.
Vicat : Initial—Not less than 45 mins. Just sinks to within 5 mm. of bottom of pat in ½ min.
Final—Fails to mark. To be within 10 hours.
Gillmore : Initial—Not less than 60 mins. Pat ½″ thick × 3″ diam. to bear without appreciable indentation a needle $\frac{1}{12}$″ diam. weighing ¼ lb.
Final—Within 10 hours : pat to bear needle $\frac{1}{24}$″ diam. with 1 lb. load.

***French.** Vicat needle 1 sq. mm. in section.
Initial—Not less than 20 mins. (needle does not wholly penetrate).
Final—Min. 2 hrs. } not appreciable penetration, e.g. $\frac{1}{10}$ mm.
Max. 12 hrs. }

German. Vicat needle *cylindrical* 1 sq. mm.
Initial not less than 1 hr. *Final* not required.

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* As shown values are for *other than* sea work. For sea work final setting is *minimum* 3 hours, *maximum* 12 hours.

During manufacture, the setting time of a cement is kept within the required limits by (1) the addition of gypsum; (2) treating with steam, or (3) combination of (1) and (2).

We are dealing with it here as received from the makers' works.

At this point the setting time of an actual sample is influenced by three variables:

(1) Amount of water.
(2) Temperature.
(3) Aeration of cement.

It must be realised that the tests for setting if properly carried out in a laboratory do not give a measure of the setting time as realised in works. The laboratory time is almost always shorter. This is due chiefly to the extra water used in practice.

In the case of certain cements where the setting time is controlled by gypsum only, prolonged storage on the site may produce the opposite effect (i.e. a much quicker set) which may more than counterbalance the retarding effect due to excess of water.

Some of these effects are shown in *Fig.* 22. These curves are plotted from data obtained by Prof. R. K. Meade.

These show variation of setting time with:—

(1) Fineness of grinding (2) Gypsum and plaster of paris	Manufacturer's arrangements
(3) Amount of water used in mixing (4) Temperature of room and materials	Laboratory conditions.

Fig. 23 is another of M. Gary's diagrams showing the change in thermal effect with setting of a cement as procured by varying proportions of the mixing water.

The effect of aeration on a cement is so marked that the comparison of the four specifications for this may well be considered here.

TABLE IX.

SPECIFICATIONS FOR PORTLAND CEMENT.

Aeration.

British.	For all tests involving mixing, except setting time. Aeration period 24 hrs.
U.S.A. ***French.*** ***German.***	None.

As will be seen Great Britain has the only specification insisting on aeration, and it is only in the latest specification (1920) that the aeration before "Setting Time" test was not made compulsory.

The effect of aeration on the setting time is well shown in Table X., taken from data of Mr. L. Gadd.

TABLE X.

Effect of Air and CO_2 on Setting Time (L. Gadd).*

	Before.				After.			
	CO_2%.	H_2O%.	Initial (mins.).	Final (mins.).	CO_2%.	H_2O%.	Initial (mins.).	Final (mins.).
Pure dry air .	·29	1·45	92	257	·3	1·41	80	260
Moist air free from CO_2 .	·41	1·98	85	325	·43	2·19	120	375
Moist CO_2 . .	·41	1·70	105	315	3·12	1·85	4	10

It will be seen that generally

Pure dry air does not materially affect the setting time.

Moist air (*free from* CO_2)—retards the setting time.

Moist CO_2 much shortens the setting time.

So the effect of aeration generally may be either to hasten or retard the setting, depending on the amount of CO_2 present.

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* Trans. *Concrete Institute*, 1913.

Some data of Mr. H. K. G. Bamber * is extremely interesting and important as giving the effect of storage in cements where setting times have been controlled by the manufacture in various ways.

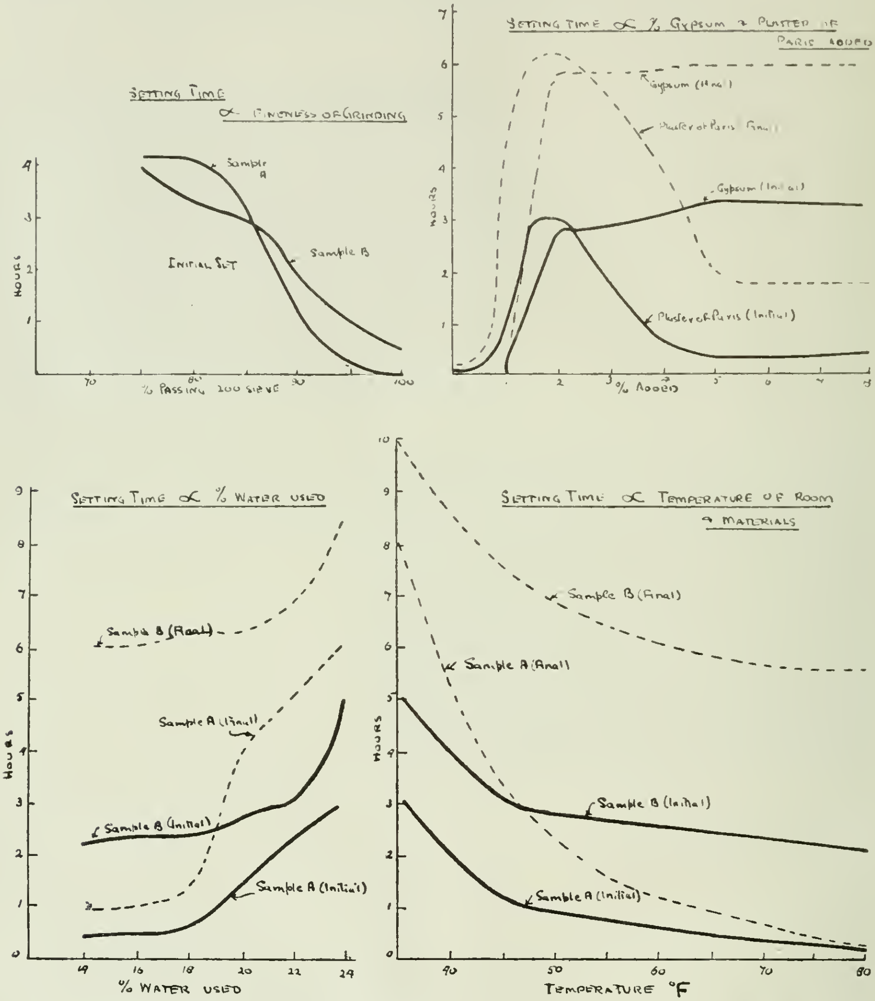

FIG. 22. SETTING TIME VARIATIONS, CURVES PLOTTED FROM DATA OF PROF. R. K. MEADE.

TABLE XI.

STORAGE AND SETTING (H. K. G. BAMBER).
(Clinker contains 0·6 % SO_3.)

	Setting Time (mins.).			
	Without Aeration.		After 48 hours' Aeration.	
	Initial.	Final.	Initial.	Final.
When ground	Instantaneous	5	Instantaneous	3
After 3 weeks	,,	3	1	15
,, 8 ,, ...	,,	3	$\frac{1}{2}$	10
,, 26 ,, ...	1	3	1	3

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* Trans. *Concrete Institute*, 1909.

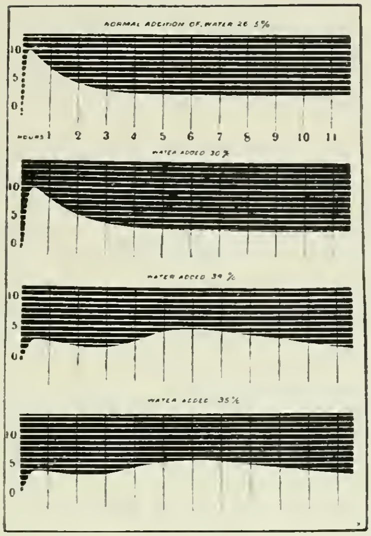


FIG. 23. PROF. GARY'S CURVES SHOWING VARIATION OF THERMAL CHANGES ON SETTING OF A CEMENT BY USING VARYING PROPORTIONS OF MIXING WATER.

Table XI. shows a cement as ground. The clinker is untreated in any way and the set is practically instantaneous even after twenty-six weeks' storage.

The effect of aeration is also shown and indicates the chaotic type of results usually experienced due to ordinary aeration.

TABLE XII.

STORAGE AND SETTING (H. K. G. BAMBER).

Cement treated with 1½ % gypsum (contains about 1·3 % SO_3).

	Setting Time (mins.).			
	Without Aeration.		After 48 hours' Aeration.	
	Initial.	Final.	Initial.	Final.
When ground	65	330	2	20
After 3 weeks	69	240	1	4
,, 8 ,, ...	1	3	2	5
,, 26 ,, ...	2	60	2	5

The next Table, XII., shows the same clinker ground and treated with 1½ per cent. of gypsum.

It will be seen that after eight weeks storage it has practically returned to its original quick set and that forty-eight hours' aeration produces similar results.

The danger of keeping this type of cement on a job is obvious.

TABLE XIII.

STORAGE AND SETTING TIME (H. K. G. BAMBER).

Same clinker as Tables XI. and XII. ground in presence of steam and ¾ % gypsum added (contains about ·95 % SO_3).

	Setting Time (mins.).			
	Without Aeration.		After 48 hours' Aeration.	
	Initial.	Final.	Initial.	Final.
When ground	55	255	40	195
After 3 weeks	58	320	48	260
,, 8 ,, ...	50	410	55	390
,, 26 ,, ...	155	510	60	380

The next Table, XIII., shows the same clinker ground in the presence of steam and then only ¾ per cent. gypsum added.

It will be seen that this treatment produces a much more "stable" cement as regards setting time.

TABLE XIV.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

SOUNDNESS.

British.	Le Chatelier apparatus. 24 hours in cold water, then 6 hours boiling. Expansion not to exceed 10 mm. after 24 hours aeration previous to test. If it fails this test further aeration for 7 days—then expansion is not to exceed 5 mm.
U.S.A.	Pats on glass, 3″ diam. ½″ thick in centre, tapering to thin edge. Stored in moist air for 24 hours. Then in steam at 98°–100° C., 1″ above boiling water for 5 hours. Any distortion shows unsoundness.
French.	*Cold test.* Pats 10 cm. diam. 2 cms. thick at centre, tapering to edges. *Hot test.* Le Chatelier. (*a*) *Sea work.* Pats and test pieces in moist air for 24 hours. The pats then immersed in sea water. *Hot test.* In boiling water for 3 hours, expansion not to exceed 5 mm. (*b*) *Not Sea work.* *Hot test.* In moist air for 24 hours, then boiled for 3 hours at 100° C. Expansion not to exceed 10 mm.
German.	Pat of neat cement kept moist for 24 hours and then immersed. It should show no distortion or blowing (this should appear after 3 days and 28 days' immersion is sufficient in any case).

SOUNDNESS.

Table XIV. shows the various specifications for soundness.

The chief is undoubtedly the Le Chatelier, though only the British and French specify this method.

This is the only British method, the French have also the cold pat test as shown.

This cold pat test is the only German test. The Americans use a pat test but subject it to steam.

What the cause of unsoundness is cannot definitely be stated. There are probably many contributory causes.

Those that may cause unsoundness in the Chatelier test may not cause unsoundness in the work.

e.g. It is not at all certain that coarse grinding of a cement will necessarily cause disintegration in a mass of concrete, though it has been shown to be sometimes the cause of excessive expansion under the Chatelier test.

There are various chemical compounds in the cement which may combine, if air has access, to form compounds which expand in formation.

e.g. Various sulphur compounds may combine with compounds of alumina to form the so-called "sulpho-aluminate"; again, a sulphide may combine with iron in the presence of air to form various compounds which have a larger volume than those from which they originated.

It is probably from fear of this type of action that the SO_3 content of a cement is given an upper limit in most specifications, though this limit is certainly arbitrary, and the only reason which can be shown for adopting these limits is, that cements containing up to these percentages are certainly sound, as far as our experience has gone at present. Far higher percentages of SO_3 than that allowed by the British standard specification quite satisfactorily pass the Chatelier test.

Table XV. gives the various specifications for chemical composition.

TABLE XV.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

CHEMICAL COMPOSITION.

British. Ratio (in chemical equivalents)
$\frac{* \; CaO}{SiO_2 + Al_2O_3}$ not greater than 2·85 nor less than 2·0
Insoluble residue not greater than 1·5%
MgO not greater than 3%
SO_3 ,, ,, ,, 2·75%
Loss on ignition not greater than 3%

U.S.A. Loss on ignition not greater than 4%
Insoluble residue ,, ,, ,, 0·8%
SO_3 not greater than 2%
MgO ,, ,, ,, 5%

French. *Sea work.* SO_3 not greater than 1·5%
MgO ,, ,, ,, 2%
Al_2O_3 ,, ,, ,, 8%
Not more than a trace of sulphides.
Hydraulic coefficient.
$\frac{SiO_2 + Al_2O_3}{CaO + MgO}$ to be not less than ·47
For Al_2O_3 content of 8% with decrease of ·02% for each 1% below 8%
Not sea work. SO_3 not greater than 3%
MgO ,, ,, ,, 5%
Al_2O_3 ,, ,, ,, 10%
Not more than traces of sulphides.

German. Ratio, by weight $\frac{CaO}{SiO_2 + Al_2O_3 + Fe_2O_3}$ Not less than 1·7
Not greater than 3% additions.
MgO content (after heating to redness) not greater than 5%. SO_3 not greater than 2½%.

This requires more discussion by chemists than engineers. It shows how little really exact knowledge exists on this subject when the very wide variation between the various specifications is noted.

Tables XVI. and XVII. give two typical analyses, one of an average sample and the other of one high in sulphur content. Both these cements were perfectly sound under the Le Chatelier test, although it should be noted that the second sample would be rejected under all the specifications considered.

TABLE XVI.

	%
Silica (SO_3)	20·73
Insoluble matter	·83
Alumina (Al_2O_3)	7·80
Ferric Oxide (Fe_2O_3)	1·92
Lime (CaO)	62·40
Sulphuric Anhydride (SO_3)	1·86
Magnesia (MgO)	·96
Carbonic Anhydride (CO_2) Water (H_2O)	3·35
Alkalies and loss	·15
	100·00

TABLE XVII.

	%
Silica (SO_3)	20·52
Insoluble matter	0·92
Alumina (AlO_3)	7·32
Ferric Oxide (Fe_2O_3)	3·31
Lime (CaO)	58·19
Sulphuric Anhydride (SO_3)	3·75
Magnesia (MgO)	2·07
Carbonic Anhydride (CO_2) Water (H_2O)	3·44
Alkalies and loss	0·48
	100·00

TABLE XVIII.

SPECIFICATIONS FOR PORTLAND CEMENT.

DENSITY OR SPECIFIC GRAVITY.

British. Not required.

U.S.A. Not less than 3·10 (white Portland 3·07).
Can be retested after ignition. Not used unless specially demanded.

---

* The proportion of lime shall be calculated allowing for proportion combining with SO_3.

French. Weight/litre used. Poured into cylindrical litre vessel (10 cm. high) through funnel.
(*a*) *Sea work*—to be at least 1200 gms.
(*b*) *Not sea work* ,, ,, ,, 1100 gms.

German. Not required

The S.G. is only now required in the U.S.A. specification, and the French one still specifies weight per litre.

The modern opinion seems to be that the test is of no practical value.

It was thought at one time possible to detect bad burning and impurities by this means.

SUMMARY.

It is now perhaps worth while trying to summarise the essential tests as considered from the conditions laid down in the opening paragraphs.

These paragraphs are repeated here for convenience :

(1) Shall give a real indication of the suitability of the cement for work in hand (setting time, soundness, strength).

(2) Shall be independent of the personal equation.

(3) Shall indicate quality in the shortest possible time.

Then all these must be considered from the two standpoints of (1) works tests ; (2) laboratory tests.

For all these tests a mixed cement pat is required ; this at once introduces the question of the amount of water to be used. This appeals to the writer as one of the most important points. Britain is the only country of these four which has no definite test for this.

Personally the Böehme hammer test appeals to the writer as being the most impersonal of the methods given though the " Vicat " plunger is simpler.

Then some definite relationship is required between the amount to be used for neat cement and the amount to be used for cement and sand.

This could be laid down in a way similar to that of France or America.

All the other tests are really dependent upon this point.

Setting Time.—For laboratory methods the Thermal measurements should indicate more fully what is occurring. For a works test and also as an auxiliary laboratory method the Vicat needle is quite suitable.

Soundness.—Whilst our knowledge of the causes of this is so vague as at present, the Le Chatelier test probably gives the maximum amount of information and appears certainly on the safe side and takes a short time (two days).

Strength.—The strength of a cement and sand mortar is all that is required, and the elaboration of a compression test seems at present scarcely required. Some mechanical means of ramming would appear to be advantageous to reduce the personal equation as much as possible.

The type of testing machine requires careful selection. Some of the older types are quite untrustworthy.

The trouble with the strength tests is the time required. It is very rarely a cement can be held up twenty-eight days before use.

All these tests as noted (except thermal) could with proper care be performed on the site of works if the percentage of water required could be mechanically obtained and the temperature conditions ensured. These two points are really the greatest difficulties on a job and have been the cause of more complaints as to the quality of cements than anything else.

SUGGESTIONS AS TO PROCEDURE UNDER PRESENT CONDITIONS.

It is suggested that probably the soundest method of specifying a cement in England at present is to specify purchase from a maker who will guarantee each consignment to be up to British Standard Specification and will send a testing certificate with it. Most firms will now do this.

On arrival on the job, each consignment may be tested for setting time, the Chatelier soundness, and fineness. If these are satisfactory there need be little fear of strength being wrong. The only test for strength required is the cement and sand, and this should be done in a properly equipped laboratory and by trained workers. It is suggested that it might be advisable to send a sample of, say, every other consignment on a small job, or every tenth on a very large job, for testing completely at a recognised laboratory.

The taking of the samples is very important and should if possible be done at the manufacturer's works. In any case, air-tight sample cases should be used and should be despatched to the laboratory with the least possible delay.

The points to guard against if purchase is made from a manufacturer of high reputation are mainly two.

First, that the certificate supplied is reporting on British Standard Specification Tests, and that all these are satisfactorily passed.

Second, that no interchanging happens between leaving the manufacturer's works and arrival on the job. This is sometimes a real danger. The writer had an experience of this just before the war where a local agent in another part of England filled bags, stamped with name of a well-known firm, with a natural or Roman cement of extremely bad quality. This arrived to the writer for test, and was, of course, rejected. The matter ended with a newspaper apology from the agent.

CONCRETE AND WATER ENGINEERING.

Some interesting particulars of, and comments on the use of reinforced concrete in reservoirs, etc., were given in the course of a number of papers and the discussions thereon at the recent Winter Meeting of the Institution of Water Engineers.

Detailing their experiences at Nuneaton, where the waterworks are built on the outcrop of the North Warwickshire coalfield, and are, therefore, particularly liable to damage from subsidence, Messrs. F. C. Cook and R. C. Moon said a brick pumping station and reservoir had been rendered unusable through cracks occurring owing to the operations of the Colliery Company, but a 500,000-gallon reservoir of reinforced concrete, built in 1906, had shown no evidence of damage whatever, in spite of the fact that it had sunk nearly 4 ft. owing to the foundations subsiding. In the case of some new reinforced concrete filter beds, although the subsidence amounted to 4½ ft., no structural fractures had occurred. In the subsequent discussion, Mr. A. B. E. Blackburn said that as the result of his experience on the North-East Coast, in districts where considerable subsidence had occurred over the magnesium limestone area, he had come to the conclusion that reinforced concrete was the only practicable material for reservoirs on unstable foundations.

Mr. George Mitchell (Water Engineer, Aberdeen), in the course of a paper on economy in design of waterworks, said concrete dams built in separate lengths with suitable joints had many advantages over masonry dams, were cheaper, and did not take so long to construct. He expressed the opinion that there was considerable scope for reinforced concrete dams of the inclined deck or multiple arch type, although so far there appeared to be only one example of this type of dam in Great Britain. He looked forward to the practical disappearance of brick and masonry in waterworks, such as had already taken place in dock, harbour and canal engineering. He was also very favourably impressed with reinforced concrete pipes; the United States Department of Irrigation had used reinforced concrete water pipes to a very large extent during the past ten years which had given excellent results and showed no signs of deterioration. He had also successfully experimented with the jointing of iron pipes with cement. Reinforced concrete was economical for roofing, and reduced the load on the floors; for the latter, water-tightness would be most economically secured by the use of concrete with a waterproof face. Replying to points raised in the discussion, the author said he thought the joints of reinforced concrete pipes were their strongest parts. His references to cement joints for iron pipes were to open socket joints, not turned and bored joints.

CONCRETE COTTAGE CONSTRUCTION.

HOUSE AT WHITELEAF.

An interesting experiment in concrete building has recently been carried out at Whiteleaf, Princes Risborough, by Mr. T. G. Davidson. During the war Mr. Davidson had occasion to use chalk-cement concrete, and he was so impressed with the excellence of the results which he obtained, that he determined to continue the use of it in England. In common with other experimenters in this form of wall construction, it was soon found that the secret of success lay in the shuttering, and to this Mr. Davidson gave considerable time and thought which has resulted in a shuttering of remarkable simplicity and efficiency.

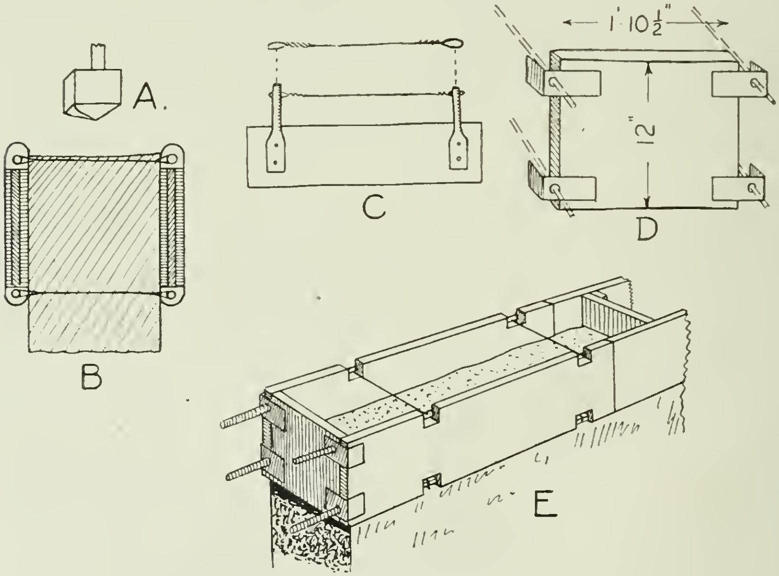


Fig. 1. Details of Shuttering.

The following description of the shuttering should be read in conjunction with *Fig.* 1. Sketch E shows a portion of the shuttering in position on the wall. It consists of boards made up into two or three varying lengths. Accurately drilled longitudinally through the boards near the top and bottom edges are holes of sufficient size to accommodate $\frac{5}{8}$ inch steel rods. Where several lengths of shuttering are erected next to each other, each rod projects a small distance into

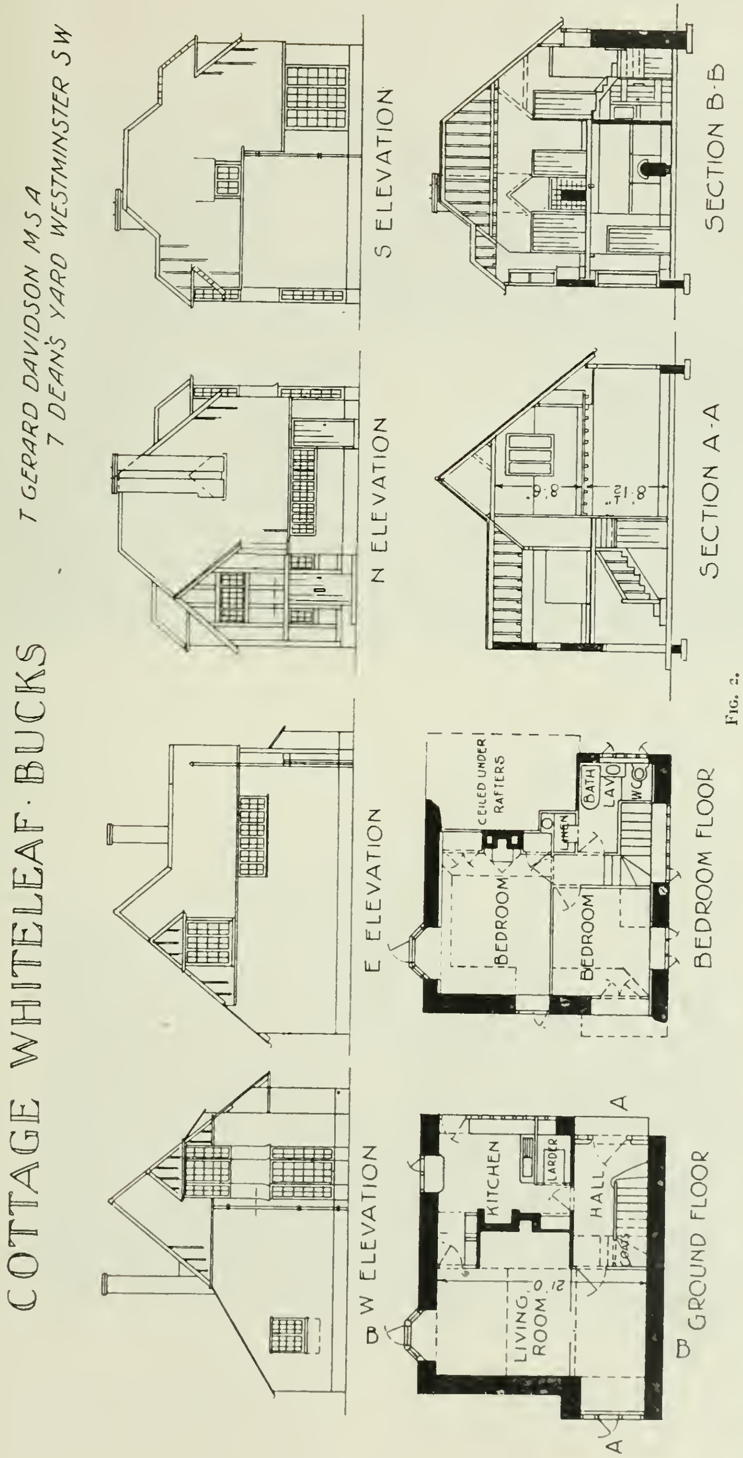
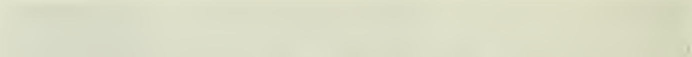

COTTAGE WHITELEAF · BUCKS
T GERARD DAVIDSON M.S.A
7 DEAN'S YARD WESTMINSTER S W
W ELEVATION
E ELEVATION
N ELEVATION
S ELEVATION
SECTION A-A
SECTION B-B
8'·6
8'·1½
GROUND FLOOR
LIVING ROOM
KITCHEN
LARDER
HALL
COATS
0 12
A
A
B
B
BEDROOM FLOOR
BEDROOM
BEDROOM
CEILED UNDER RAFTERS
LINEN
BATH
LAV
WC

Fig. 2.



Figs. 3 and 4. View of Finished House at Whiteleaf.

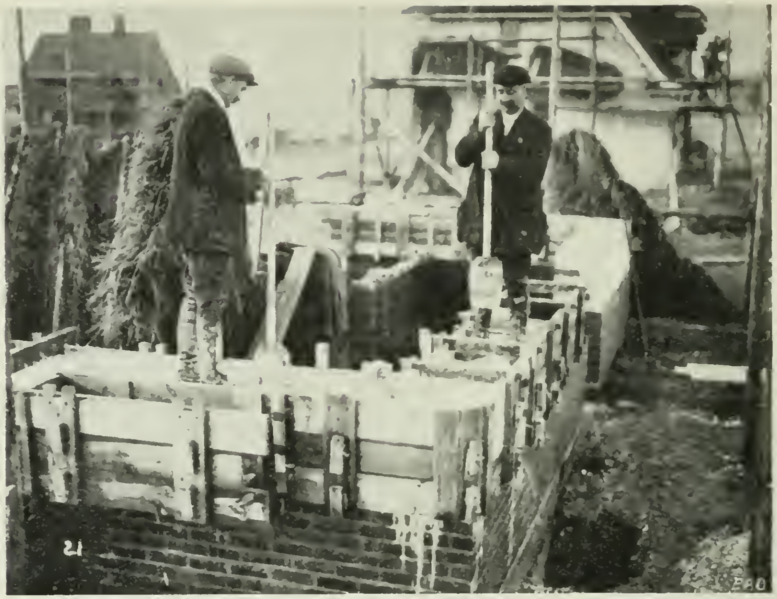
the adjacent board, thus maintaining true alignment. At intervals on each board notches are cut and as the rod is passed through these a looped wire is threaded on, in this way so soon as any concrete is tamped between the boards they are held rigidly in position. Great care is taken in making up these wires, and for this purpose a special adjustable jig is made (*see Fig.* C), so that the length of each wire loop is identical for any one thickness of walling. In this way the stress is equally divided amongst the wires which are all kept equally taut, thus ensuring a plumb wall. The shuttering is a climbing one, and so soon as a piece of walling is completed the lower rods are withdrawn and the boards hinged up on the upper rods. The wires are left in the wall, being cut off flush as the work proceeds. Sketch A shows a rammer used on the chalk-cement concrete house, and B is a section through the piece of wall and shuttering; the section being taken through the notches it shows the rods passing through and the wire loops around them. It will be seen that in this case the shuttering is made up of three thicknesses of timber. Sketch D shows an end piece, iron angle pieces are attached to the board between which the shuttering fits. Where it is required to stop off a piece of walling, a board is inserted between the shuttering and held in position by fixing a temporary fillet as shown in sketch E. Mr. Davidson has patented his shuttering, which is known as the Self-Mounting Shutter.

Fig. 2 shows plans and elevations of the house. The thickness of the outer walls should be particularly noted; these are 1 ft. 10½ in. up to the first floor, where they are reduced by the width of the plate, 4½ in., to 18 in. By adopting such a method of building it is possible to obtain the fine effect that is the result of building with such a thickness; it forms a particularly welcome change from the growing tendency to make walls ever thinner and thinner until they become little more than a layer of asbestos sheeting. Another distinct advantage of the thick wall, apart from the delightful appearance of deep windows and door soffits, is the warmth in winter and the coolness in summer that such a protection affords. Views of the house are shown in *Figs.* 3 and 4; it will be noticed that the shuttering has been adapted to irregularities of outline, and that it has not been necessary to adhere to the box shaped plan with the lid roof. The lines of the shuttering are faintly discernible on the walls.

CONCRETE HOUSES AT AMESBURY.

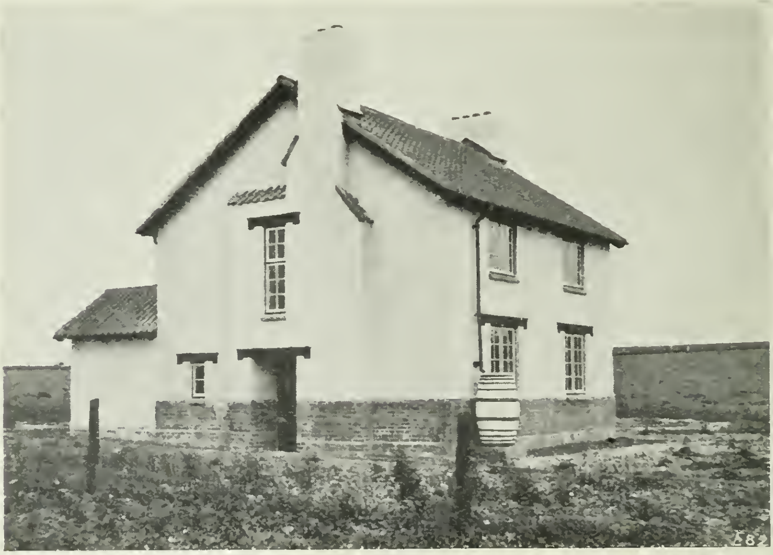
At Amesbury several concrete cottages have been erected by the Ministry of Agriculture and Fisheries under the direction of the Scientific and Industrial Research Department. *Figs.* 5 and 6 show a chalk cement concrete cottage. The mixture employed is 20 to 1, and no water is added, the natural moisture in the chalk being sufficient. The walls, which are 18 in. thick, are worked and tamped in a similar manner to pisé walls; the ramming process will be seen in *Fig.* 5. In the case of this particular house the brick plinth was taken to an unnecessary height, all that is required, however, is a solid ballast concrete wall to damp-proof course level. It will be noticed that the stacks are constructed in the same material and not in brickwork. The outside of the main building is cement rendered; it was decided, however, not to pursue this course for the outbuilding to which no protective coat has been added. The shuttering employed is one devised by the Department Officers.

Fig. 7 is a reinforced concrete house also built by the Research Department.



By permission of the Building Research Board.

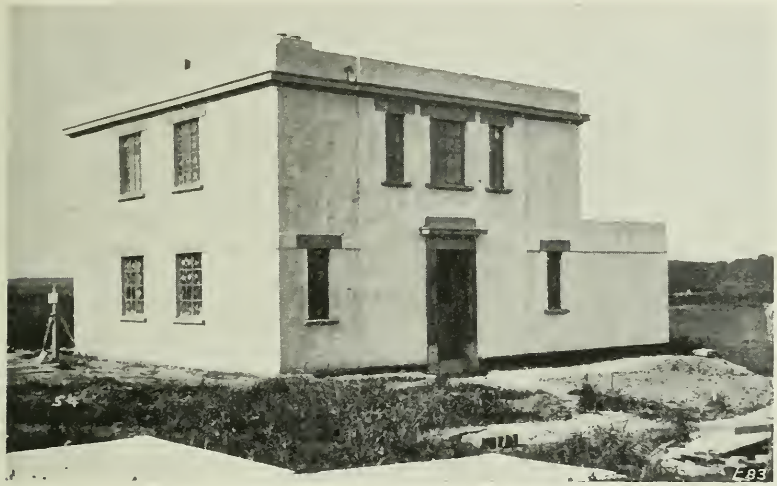
Fig. 5. Chalk Concrete House at Amesbury showing Shuttering.



By permission of the Building Research Board.

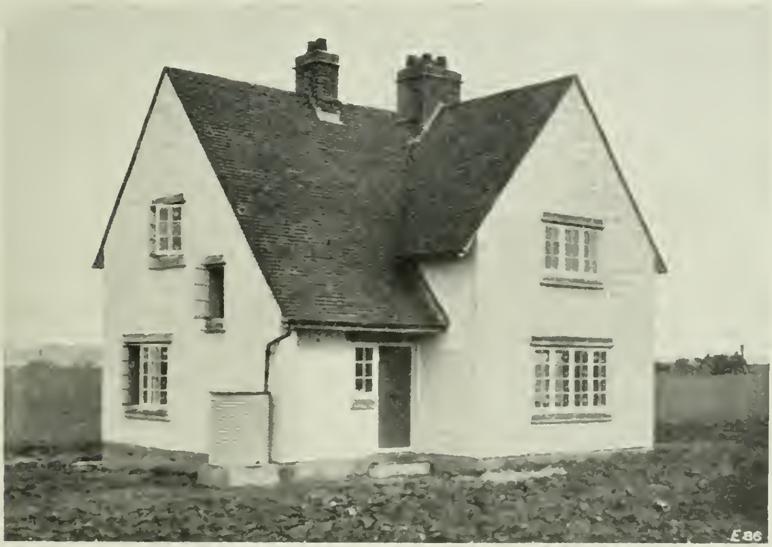
Fig. 6. Chalk Concrete House at Amesbury.

The walls are solid, without a vertical damp-proof course, and particular note is to be taken as to the tendency towards condensation which this building may exhibit. The roof is built up of reinforced trusses between which is Hy-Rib expanded metal covered with concrete and laid to a fall, the chimney stacks are of concrete, likewise the risers to the staircase, and the first floor, in fact the use of timber has been reduced to a minimum. *Fig.* 8 illustrates a house built by the Ministry of Agriculture and Fisheries. The method employed here is chalk concrete



By permission of the Building Research Board.

FIG. 7. REINFORCED CONCRETE COTTAGE AT AMESBURY.



By permission of the Ministry of Agriculture and Fisheries.

FIG. 8. CHALK CONCRETE BLOCK HOUSE, AMESBURY.

blocks. These blocks were made in the ordinary way in a "Dri-crete" machine, the mixture being 12 of crushed chalk to 1 of cement; an ordinary cavity wall construction is used. No protective covering has been placed over the outside surface and in the illustration the joints of the block are clearly visible. This is being done in order that the weather-proof qualities of the material may be tested; it is possible, however, to add a protective coat should this prove necessary. and the brick window heads and sills have been set with a slight projection beyond the block face for this purpose.

All these experiments in chalk concrete construction are of great interest and may prove of real value. The proportion of cement is so small, that where chalk is obtainable on or near the site the method of building should be a cheap one. In both the 20 to 1 rammed chalk and in the 12 to 1 blocks no water is added to the moisture, it being found that the natural moisture in the chalk is sufficient hydration. Experiments have also been made in chalk-pisé without the addition of cement, in this case a certain amount of soil is added. This matter, however, is one hardly coming within the province of this article.

CHEPSTOW HOUSING.

In our issue of June, 1920, there appeared a detailed account of the housing developments at Chepstow and the surrounding villages, which constitute such a striking example of concrete work, perhaps one of the most extensive and most successful in England. The vicissitudes through which the shipyards have passed have been many, and when at the termination of hostilities in 1918 the Government, who had by then acquired all the shipbuilding interests in the districts, abandoned this great scheme, there seemed a danger that the yards, and consequently the fine new villages, would become abandoned. Fortunately, however, the Monmouth Shipping Company, which was formed in the spring of last year, took over the yards, together with almost the whole of the new villages of Hardwick and Bulwark, both on the outskirts of Chepstow, and the smaller village of Pennsylvania on the Ledbury side of the river. The price paid was £400,000 for the three villages, comprising some 475 houses. An aeroplane view of Bulwark is shown in *Fig.* 10. The main road running through the centre is The Avenue; a finely planned road fifty feet wide. Ultimately this

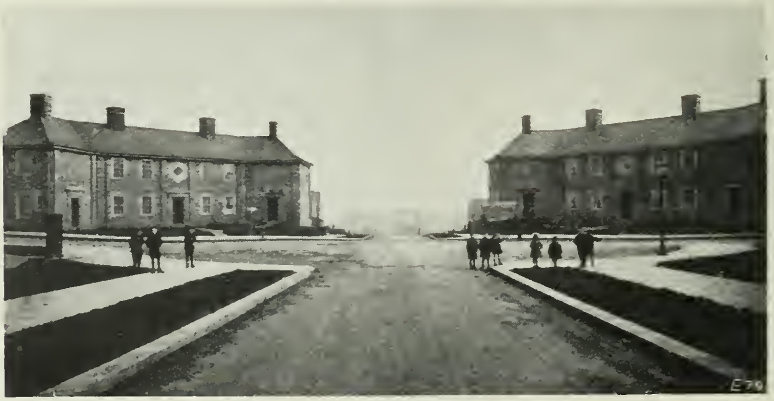


Fig. 9. The Octagon, Bulwark Village.

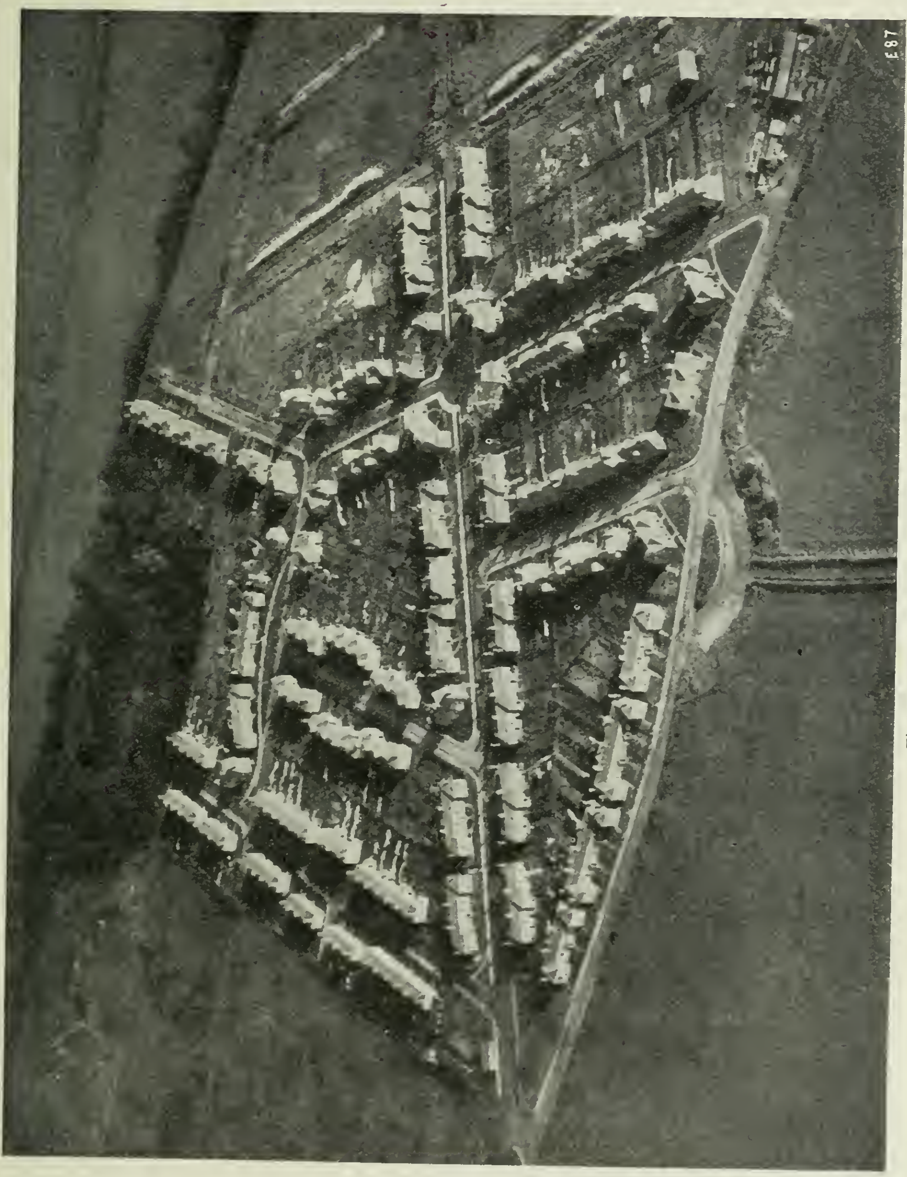


Fig. 10. Aeroplane View at Bulwark.
Chepstow Housing.

road will terminate with a circular space in the middle of which will be placed a band-stand. An imposing feature of the layout is the Octagon, which is clearly seen in this photograph, and of which a detailed view is given in *Fig.* 9. The aerial view shows very clearly the enhanced effect obtained by skilful grouping of the houses, by the formation of crescents and axial planning, so that the various roads terminate on some feature of interest. Another type of house is illustrated in *Fig.* 11, and in the background of the same photograph can be seen a different treatment, so that it will be appreciated that the variety is very great. All the houses have been constructed of blocks made on Winget machines. The size of these has, fortunately, been kept small, so that the scale of the building is not destroyed. Moreover, since the aggregate is largely composed of crushed stone they have a warm pleasant colour. During the last two years the concrete has improved during the process of weathering, and the whole town has acquired a mellower and softer tone; it is indeed fortunate that a great opportunity was not missed, as it might so easily have been, and instead of these buildings, which harmonise so well with the old stonework of Chepstow, a mushroom growth of hideous terraces might have defaced the landscape, one of the most beautiful in England.

The rents of the houses at Bulwark vary from 9*s*. to 25*s*. per week, including rates. The architect for the scheme was Mr. Henry E. Farmer, F.R.I.B.A., now Housing Commissioner at Birmingham under the Ministry of Health. The contractors were Messrs. Henry Boot & Sons.

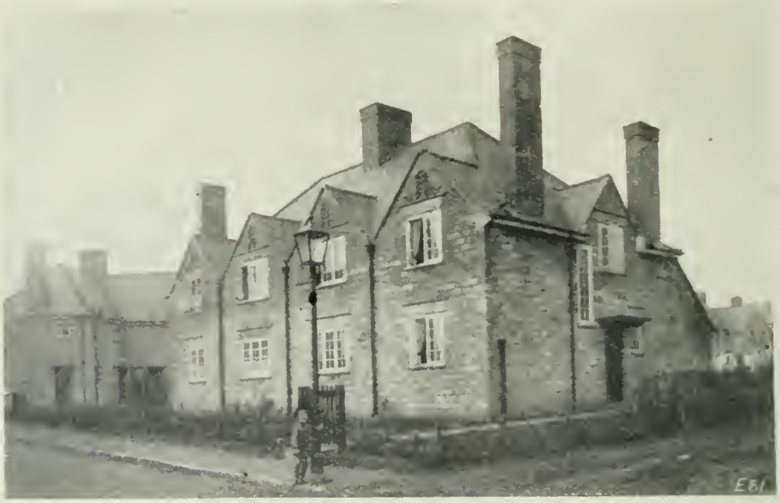


Fig. 11. Houses, Victoria Road, Bulwark.
Chepstow Housing.

Reconstruction in Belgium.—Although Belgium is peculiarly well placed as regards building materials and relatively cheap labour, the reconstruction of the devastated areas is proceeding very slowly. Prices are likely to fall still further, but even then substantial buildings will be too costly.

For some of the farmhouses, repairs are being made of reinforced concrete, the outer walls still standing being used as far as possible, and internal walls being made of metal mesh covered with concrete after erection.—*Béton Armé.*

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

RECENT ELECTIONS INTO THE INSTITUTE.

Honorary Member :—Miss Elizabeth Frances PUTZ, Editorial Secretary, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

Members :—
Albert Edward GOSLING.
Waldo Emerson GUY.
Henry Major HALE.
Alfred Thomas Blakey KELL.
Charles Robert PORTER.

Associate-Member :— Bansi Ram SEENGAL.

INTERNATIONAL BUILDING TRADES EXHIBITION, April 12th–26th, 1921.

Wednesday, April 13th, at 1.45 (for 2.0) p.m., members will assemble in the Welcome Club Rooms, when Mr. A. Alban H. Scott, M.C.I., has kindly consented to organise parties to be conducted by competent guides to inspect the most interesting stalls. At 4.30 p.m. in the Lecture Hall, Mr. H. Kempton Dyson, M.C.I., will read a Paper upon " Building in Concrete."

Tuesday, April 19th, at 1.30 p.m., the Council of the Institute will give a luncheon in the Pillar Hall at Olympia. The Rt. Hon. Christopher Addison, M.P., and the Rt. Hon. Lord Riddell will be guests of the Institute. Mr. G. Topham Forrest, F.R.S. Ed., F.R.I.B.A., and Sir James Carmichael, K.B.E., have also been invited as guests. After lunch, Mr. A. Alban H. Scott will speak upon " Building Bye-Laws and Regulations." Tickets for the luncheon can be obtained from the Secretary of the Institute, price 6s. each, exclusive of wines, etc. Early application should be made.

By the courtesy of the management the Institute is allowed to make use of the Welcome Club Rooms during the period of the Exhibition.

Tickets for the Exhibition can be obtained from the Secretary of the Institute.

CLASSES IN STRUCTURAL ENGINEERING.

We have received the additional information as to classes in the above :—LONDON COUNTY COUNCIL SCHOOL OF BUILDING, Ferndale Road, Clapham, S.W., Mondays to Fridays, 7.30 p.m. to 9.30 p.m., according to subject.

Mechanics of Building and Strength of Materials, Drawing and Design of the Structural Steelwork of Buildings, Reinforced Concrete and Structural Engineering applied to buildings.

Lecturers :—Messrs. E. G. Beck, Wh. Ex.,A. M.Inst.C.E. ; H. Kempton Dyson, M.C.I., M.Int.Assn. Testing Materials ; R. Graham Keevil, M.C.I., A.M.I.Mech.E., and W. Russell.

LECTURES AT THE CONCRETE INSTITUTE.

Thursday, April 28th, at 7.30 p.m., Paper by Prof. F. C. Lea, D.Sc., on " The Elastic Modulus of Concrete " (Lantern).

Thursday, May 26th, Paper by Mr. Lawson S. White, M.C.I., on "Land Subsidence and its effect on Concrete and other Structures."

THE ANNUAL GENERAL MEETING will be held on Thursday, May 26th, 1921, at 7.30 p.m., prior to the last-named Paper.

CONCRETE AGGREGATES.

We publish a letter received from one of our members, as follows :—

"May I be permitted to correct a slight inaccuracy in the valuable particulars of local aggregates now being published in CONCRETE AND CONSTRUCTIONAL ENGINEERING.

"In the December, 1920, issue, p. 804, it states :—

"'Cornwall. The felspar obtained from the refuse heaps of china clay washings is contaminated with clay, thus making it unsuitable for first-class concrete.'

"These refuse heaps are not composed of felspar contaminated with clay, but of quartz contaminated with disintegrated felspar (china clay), mica, etc., but apart from this little inaccuracy the classification is correct, and the sand is certainly not suitable for first-class concrete.

"In many districts, however, this material is to be found in beds where it has been deposited by the rivers, and having been washed for centuries, is free from all impurities.

"The writer has such a high opinion of the sand from these sources that he is now sending it from Cornwall to S. Wales for use in important Reinforced-concrete structures.

(*Signed*) "GOWER B. R. PIMM."
M.C.I., A.M.Inst.C.E.

(34) **Farnham (Surrey)** :—Gravel and sand, containing 12 per cent. loam. (R.C.B.)*
(35) **Felixstowe (Essex)** :—Beach shingle. Excellent. (R.C.B.)
(36) **Flint (N. Wales)** :—Crushed spar from lead mines, containing sulphur and other impurities. (R.C.B.)

Correction :—In the September issue, 1920, under (11) Bolton, it should read as "Stone" instead of "Sand."

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* R. C. Branston (see notes in previous issues).

THE GEOLOGY OF CONSTRUCTIONAL STONE.

By J. ALLEN HOWE, O.B.E., B.Sc., etc.

The following is an abstract from a Paper read at the One Hundredth Ordinary Meeting of the Concrete Institute.
The Paper was illustrated by lantern slides and an interesting discussion followed.
Mr. E. Fiander Etchells, the President, was in the Chair.

BY the geology of building stones we mean the application of geological methods to the study of constructional stone, and this study may be said to embrace :—1. The geological distribution of stone. 2. The effect of geological structures on the economics of quarrying. 3. The petrology of stone. 4. The chemical and physical properties of stone. 5. The decay and wear of stone. 6. The testing of stone.

Clearly it is not possible here to give adequate treatment to even one of the subjects, and only a rough sketch indicating their relationships is here attempted.

The Distribution of Stone.—There is now a markedly growing tendency in this country to consult geological maps when new sources of stone are required.

But the geological distribution of stone of specific character is by no means the same thing as the localisation of rocks of the same geological age. It does not follow that a formation in which a good stone is found at one spot will contain stone of a similar quality elsewhere. Portland stone, to take a familiar example, occurs in the Portland formation, which is traceable from the Isle of Portland to Oxfordshire, while stone of "Portland" quality is found only in the Isle of Portland and the neighbouring coast of Dorset. When the formation is followed no farther than the Vale of Wardour, though extensively quarried there, the type of stone is quite different, and if we trace the outcrops further afield we shall search them in vain for true Portland stone.

The exploiter of stone requires, therefore, more definite indications of quality than can usually be put upon a geological map.

Quarrying.—When we turn to the quarrying of stone we find that due comprehension of the geological circumstances is a matter of some importance. The economic development of the quarry, the avoidance or disposal of waste, the drainage and cost of operation, as well as the quality of the product are more often than not closely related to these circumstances.

Rock Types.—Rocks fall naturally into two classes, igneous and sedimentary, each, from the technological as well as the academic standpoint, possessing characters peculiar to itself.

The sedimentary rocks employed in construction are classable, with unimportant exceptions, as sandstones and limestones.

The sand grains that normally make up the bulk of sandstones, being derived from pre-existing rocks, are composed of their more resistant minerals, quartz predominating. Some sandstones contain no other essential mineral, while others carry more or less felspar and mica besides accessory minerals of no technical significance.

From the point of view of the engineer and architect the binding medium or the character of the bond between the quartz grains is the feature in sandstones requiring most attention. The grains are usually held together by secondary mineral growths composed of materials derived either in part from the grains themselves or introduced by mineral-bearing solutions. The best and most prevalent binder is silica; others are calcite, iron oxides, clay, and in rarer cases a variety of other minerals; frequently several of these binders are operative in the same stone. A sandstone with a predominant calcite binder behaves under chemical attack like a limestone, but without that stone's good qualities.

Besides the nature of the binder the state of aggregation of the grains is an important characteristic; great differences in porosity and grain cohesion are caused by the presence or absence of an inert filling between the grains and by the degree of compression and compacting of the grains.

The majority of limestones employed in construction were originally organic in origin, but they have usually undergone internal changes, such as the partial solution of the calcareous shells and fragments accompanied by re-crystallisation of the calcite.

Two types of limestone deserve special notice, the oolites and the magnesian limestones. Oolites are built up largely of rounded grains of concretionary origin; stones of this kind are well-known and valued building stones.

Magnesian limestones are composed of calcium and magnesium carbonate, the latter being combined with calcium carbonate as the double carbonate, dolomite, which tends to crystallize in well-defined rhombic crystals, giving the stone a "sandy" feel. Every gradation is found from a calcareous limestone with a few rhombs of dolomite to a pure dolomite rock. The mineral dolomite is rather more resistant to solvents than calcite.

Metamorphic Rocks.—By the effect of mechanical deformation and heat any of the rocks mentioned above may be so altered or "metamorphosed" as to cause them to take on entirely new characters which places them in a class apart, namely, the metamorphic rocks.

One of the most important characteristics of these rocks is the fresh orientation and re-growth of the mineral constituents which may introduce the quality of fissility in one or more planes in some cases and greatly increases the toughness and strength in others.

Chemical Properties of Stone.—All stones are built up of minerals of known composition; therefore if we can recognise the minerals that constitute a stone and estimate their relative proportions, we can then estimate its chemical composition with sufficient accuracy by mere inspection. This can be done by cutting a thin slice and subjecting it to microscopic examination.

The Disintegration and Wearing of Stone.—In all situations stone suffers more or less chemical disintegration. Granites and sandstones with good siliceous bond suffer least from chemical wear; limestones and sandstones with a calcareous bond suffer the most. All stones with a fissile tendency are prone to develop this character on exposure. Much of the superficial wear of granites and limestones is due to the gradual opening out of the minerals that possess a highly developed cleavage, such as the felspars, calcite, micas and amphiboles.

Testing.—The two properties of stone about which we commonly require information are its *strength* and its *durability*. For the first it is customary to investigate the behaviour of the stone when subjected to pressure, tension, shearing, and so on. An estimate of the second quality is a more complex and difficult problem.

Taking first the tests of mechanical strength we find that the most commonly applied test is that of compression. Now this test, though apparently so simple, is beset with difficulties, and as a rule too few blocks of a kind are tested.

How great the variability may be is exemplified in some of the test records of the Charlottenburg laboratories; thus, in 60 different kinds of granite, test pieces from the same quarry showed an average individual difference of 31·6 per cent.

2	kinds showed differences of	2 to 10	per cent.
6	,, ,, ,,	11 ,, 20	,,
23	,, ,, ,,	21 ,, 30	,,
21	,, ,, ,,	31 ,, 40	,,
6	,, ,, ,,	41 ,, 60	,,

and some gave even higher differences.

Discrepancies of a similar kind are shown in the results for other kinds of rocks.

Merrill gives figures showing the following results for the three principal stone types, in lb. per square inch:—

	Max.	Min.	Average.
Granites, 100 tests	28,000	6,117	17,000
Limestones, 80 tests	25,000	3,550	14,000
Sandstones, 132 tests	20,000	1,149	8,500

The transverse strength of stone, or its resistance to bending should be, as experience in buildings proves, a more useful test though it is not so frequently performed. The Canadian tests provide the latest long series of tests available.

Baldwin Wiseman has published results for a number of British stones.

Tests on the elasticity of rocks have not been very numerous, probably the best are those of Adams and Coker. A few British stones were tested by Prof. Hudson Beare.

In spite of the fact that stones in buildings yield to shearing stresses more often than to pressure, comparatively few results of shearing tests are available.

The tensile strength of stone has been to a great extent ignored, mainly on the quite reasonable ground that stones within a structure are practically always in a condition of pressure and rarely of tension. Hirschwald, however, has shown that very useful results may be obtained by the tensile test, carried out in the same manner as for cement.

Determination of the specific gravity is required for the measurement of the stone's porosity, a very important character, for it has been well established that the more porous stones are the least resistant to the evil effects of moisture and frost. In this connection we have to remember the difference between the larger and the smaller pores.

Neither the water absorption nor porosity must be confounded with the *permeability*, for this depends not alone on the amount, but on the character of the pore space.

The influence of the softening effect due to absorption of water may be expressed as the ratio of the work to be done on the wet stone to that done on the dry stone when tested under similar conditions. This influence has been tested by compression, tension, grinding, rumbling, boring and the sand-blast. In all types of stone there is a distinct decrease in strength in the wet state, and figures obtained by the different methods of testing yield fairly concordant results.

The action of frost on stone is in some situations a familiar cause of disintegration, and it has been the subject of much experimental work.

The attack of frost on stone is affected by the presence of cracks, by the size of the pores and the total amount of pore space, but most of all by the content of water at the time of freezing. It has been conclusively proved that the stones above the ground-line in buildings hardly ever contain even half their maximum content of water. The pores must be over nine-tenths full if frost is to exert an effective pressure ; consequently it is the fine pores—those that hold the water—which count in above-ground structures, and the coefficient of saturation is now being generally accepted as the most convenient criterion of the frost-resisting quality of a stone.

The corrosive action of strong acid vapours and weak acid solutions has often been tried upon stone. Here again the action is too drastic if the acids are strong and is too slow if the solutions are weak.

Parker, who carried out the Canadian tests, has found the following procedure give results which he pronounces satisfactory. The stone is dried at 100° C., measured and suspended in water through which a current of CO_2 is passed ; the water is renewed every four days, and the process is continued for four weeks. At the conclusion of the test the stone is washed in distilled water and rubbed lightly over with the fingers, dried and weighed, and the loss per square inch determined,.

A simple test employed by Hirschwald, capable of yielding useful information on the permeability and structure of the softer stones, is that of soaking equal sized test pieces in an alcoholic stain. After drying, the stones are cut open and the character of the internal staining is observed.

The " hardness " of stone, or its resistance to mechanical wear, has been tested in a variety of ways ; for example, by grinding with abrasive on a rotating disc, by boring, by the sand-blast, by scratching and by the Brinell test.

In the case of road-metal, and the tests are also applicable to material for concrete, certain tests have been more or less standardised in America and this country. For the " attrition " test a rumbling machine of the Deval type with four cylinders is used. The charge consists of 11 lb. (5 kilos.) of stone, composed as nearly as possible of 50 pieces, and the drums are given 10,000 revolutions at the rate of 30 per minute. In the wet test 1·1 gallons (5 litres) of water are put in along with the stone. The percentage loss is estimated from the amount of material removed that will pass a sieve of one-sixteenth inch mesh. The French coefficient of wear is $\frac{40}{\%\text{ loss of weight}}$.

For the " abrasion " (or hardness) test a machine of the Dorry type is employed. Cut cylinders of stone, 1 in. long and 1 in. in diameter, are maintained at a constant pressure against the surface of a cast steel disc fed continuously with crushed quartzite, and the loss of weight determined after 10,000 revolutions at about 28 per minute. The American coefficient of " hardness " — 20 — loss of weight in grams 13.

Toughness is measured by the behaviour of the stone when tested in the Page impact machine. The test pieces are cylinders cut as for abrasion. The hammer of the impact machine weighs 4·4 lb. (2 kilos.) ; for the first blow it is allowed a fall of 0·4 in. (1 cm.), and this is increased by the same amount for each succeeding blow until the stone fails. The number of blows is the measure of " toughness."

Hirschwald and Brix studied the behaviour of road-stones when subjected to direct pressure and they measured the amount of the different sizes of stone produced. The results were also compared with material taken from the roads.

In the case of waterbound roads the " cementation " test is of interest. The method adopted by the National Physical Laboratory is to grind the stone in a standard ball mill, and from the material prepare six briquettes under a pressure of 1,880 lb. per square inch. These are dried for 24 hours and then broken under the Page impact machine.

Having dealt with some of the methods of testing stone, though in a very imperfect manner, we may ask ourselves how far do these tests go towards providing a reliable measure of the comparative merits of stone for use in different types of structure and in diverse situations ?

As regards the purely mechanical properties, the tests, when performed under standard conditions, undoubtedly yield results that may be of value in specific cases. At any rate, with these mechanical tests we have something we can measure in a straightforward way.

But the mechanical strength has often little to do with the durability of stone, and when we set ourselves to measure this quality we are faced with a series of *imponderabilia*, or at least, with a number of factors extraordinarily difficult of evaluation.

Pfaff, Hilger, Schutze, Bissinger and others have carried out long-duration weathering tests on stone, and thirty years have been reckoned none too long a period for such investigations to bear fruit. But by far the most detailed, logical and scientific attempt to find a solution to the forecasting of weather-resistance and durability is to be found in the elaborate labours of Hirschwald. His mode of attack is theoretically sound, but the complexity of the scheme is appalling.

Rosival's method of determining the weather-resistance was based upon his planimetric measurements of the individual mineral components combined with the determination of their respective hardnesses. Thus, he took the theoretical hardness (H) – $p_1h_1 + p_2h_2 + p_3h_3 \;\ldots\; \epsilon\, p_nh_n$, where p_1, p_2, etc , were the percentage volumes of the minerals and h_1, h_2; their respective average hardness The effective hardness (h) was determined from the loss of volume after grinding the stone in a prescribed manner. The freshness (F) of the stone he represented as h H, while the degree of weathering (V) or loss of " hardness " $= \frac{H - h}{H}$.

Here again, though the theoretical basis may be accepted the technical value of the method is out of all proportion small when compared with the labour involved.

Finally one is driven to the conclusion that while it is possible to learn much about the qualities of stone by the methods discussed, it does not appear possible to grade stones according to their weather-resistance or durability by any reasonably short process.

DISCUSSION.

Sir Henry Tanner, C.B., in referring to the last part of the paper dealing with the weathering qualities of stone, said this question had been of some interest to him on many occasions when erecting buildings all over the country and selecting the stone, because it was a very difficult thing to find stones which would weather properly in various towns, especially in the smoky towns of the north, where the effects of weather on the stone were worse than anywhere else, even London. He had always endeavoured to find his stone somewhere in the neighbourhood in which the building was to be erected. In Yorkshire good stones could be obtained which seemed to wear very well in places like Leeds, Bradford and Halifax, but in that district they were nearly all sandstones, and many of them needed to be treated in order to afford some sort of protection against the weather. He had tried one or two systems, but whether they had answered or not he was unable to say at the moment. After all, we seemed to come back to Portland stone for the bulk of the big buildings, even in Manchester and Liverpool, and it seemed to be the best stone for this purpose. The great point in its favour was the ease with which it was always possible to obtain the necessary quantity. With regard to the photograph of a stone step with the top layer peeling off, which had been shown on the screen, a large part of the Yorkshire stone was laminated, and required very little inducement to break off, but some Yorkshire stone could be obtained with very little lamination. That, however, was very difficult to obtain, and was much dearer, but he had always thought it worth the money and had used it when possible rather than the cheaper variety. He asked whether the author had had experience of methods of preventing the disintegration of stones.

Mr. W. J. H. Leverton, Licentiate R.I.B.A., referring to Sir Henry Tanner's remarks on Yorkshire stones, said he had noticed that in some cases in London they did not stand so well, and that corroborated the view that a stone stands well in its own district, but not so well in another part of the country. Bath stone stood very well in Bath, though not so well in London. With regard to the photograph shown on the screen and taken at Charlottenburg, in which the stones above the plinth had gone very badly, the speaker inquired whether there was a damp course, because if not, the tendency of the dampness must have been upwards.

Mr. C. H. Colson, O.B.E., said he thought the paper almost started a new era in building stone selection. In the past they had been practically forced to find out what had happened to various stones after they had been used for some time in order to select their stones, and that had been the best guide possible. That, after all, was more or less rule of thumb, and it seemed to him to be possible that, by acquiring greater knowledge of the characteristics of the various stones, the way in which the different grains were tailed into each other and the character of the matrix, in the future we may be able to evolve tests which would allow us, with some degree of certainty, to select building stones. With regard to lavas, Mr. Colson said there were many different lavas, and he would like to hear whether any were used in this country.

The speaker also asked the author if he would say a word or two as to what happened in regard to the re-crystallisation of the surface of rocks of the neolithic type. The upper portions of it were very open in grain, the grain was quite round, and probably connected with calcite in little ridges, but the lower portion seemed to have been formed in shallower water, possibly with a considerable amount of large organisms, but the whole of the interstices filled with calcite. Has this been washed down from the upper layers into the lower or has it been formed in the lower layers? The upper layer was quite unreliable as a weathering stone, whereas the lower layer wore extremely well.

Mr. H. F. Bladen, M.C.I., said he was not familiar with the question of the wearing of stones, but he had been told by builders that weather made a kind of cement on the surface of certain porous stones.

He had lived in a house at one time where the weather drove through certain stones in the front of the house, and when the builder told him of this, and that it would stop, he thought it was due to his optimism, but in point of fact the weather stopped driving through. He would like to know whether that was a fact, and whether it had any significance with regard to the wear of stones.

Mr. H. G. Lloyd, referring to the freezing tests, said he would like to know whether the stones shown on the screen were completely filled or saturated with water before subjection to the freezing tests or whether they were less than nine-tenths full of water, so that the tests should be more comparable with what would be likely to occur in the actual weathering of stones.

The President asked what was the latest view as to the origin of flint.

THE LECTURER'S REPLY.

Mr. Howe, in replying to the discussion, referred first to Sir Henry Tanner's remarks about the use of Portland stone in the northern counties. The general aspect is a sandstone aspect, and it certainly seemed very suitable, but it would accumulate the dirt, of which there was plenty there. There appears no reason why Portland stone should not behave as well there as in London. From the building stone point of view the first thing to do rested not with the engineer, but with somebody else who would settle the atmosphere of the towns. If that were settled the whole trouble really went. The purely mechanical properties of stone could be easily dealt with by the engineer, but it is necessary to find out what the stone has to suffer in a building and what it has to bear. Quite a number of points arose in this connection, one very important factor being draughts ; they have an extraordinary effect, even inside buildings. Sir Henry Tanner had suggested preservatives after atmospheres, but although these merit consideration we have as yet hardly enough experience of the different types of preservatives to form a proper judgment. More co-operative and organised investigation is still needed on this point before we can arrive at definite conclusions. Materials of some kind were essentially necessary, but our knowledge is still too small to say clearly and honestly what would be correct.

With regard to the plinth, mentioned by Mr. Leverton, that had a damp course. It was really a question of the position of the pavement round about it, which allowed the soaking rain water to lie there a little longer than usual.

Coming to Mr. Colson's question as to tests, the lecturer thought he had more or less tried to answer that question. He had suggested what he thought was one of the most reasonable tests and the least expensive. He did not believe in prolonged and elaborate tests, they do not seem to be worth the money and time spent on them. As to lavas, there were very few used in this country. They had not much strength, and no one, except under extreme provocation, would think of using them, although there were some in the west of England and in Scotland. With regard to re-crystallisation, in the particular case mentioned, Mr. Howe was inclined to think that in the upper part of the stone the calcite had been removed. Frequently the upper part had been more exposed to the weather. The calcite in rocks of that sort moved about with extraordinary freedom, and there was solution, re-solution and re-disposition taking place at any and all times in the earlier stages of formation.

Referring to Mr. Bladen's point as to the skin on the stone and permeability, practically all stones in the first place were permeable to water and gases, and the latter to an extraordinary extent, and as they altered by weathering the permeability decreased. Probably what happened in this particular case was concentration of the soluble matter in the stone, which came to the surface and clogged up, to some extent, some of the pores.

With regard to freezing tests, those mentioned in the paper were carried out with stones in a saturated condition. The question of the amount of water is always a debatable point in this connection, but the only way to get real information is to have the stone either bone dry or really saturated, because the other stages are difficult to get with uniformity in the different stones. It is possible to get uniform conditions with one particular stone, but when the test is applied to stones of different character the difficulties are insuperable. Practically all testers had their specimens practically full of water, which was the worst possible condition for submission to a freezing test. In the natural state in the building, comparatively, the stone really has not enough water to do any damage.

The lecturer said he was afraid he did not know much about the origin of flint, although there was a great deal of literature on the subject. The old theories practically held ground yet, i.e., that a lot of flints had been formed in the rock in two ways, either quite early, when in the soft condition—and in some cases that probably was the case—and in other cases, without any doubt, they were formed at a later stage by the passing of silica solution from point to point and concentrating at centres which acted as gathering grounds for the colloid structure.

A hearty vote of thanks was accorded the author.

MEMORANDUM.

Joints in Concrete Roads.—A method of concealing the joints between each day's work has been successfully adopted in the construction of a concrete road in Vancouver. A strip of ½-in. board was placed against the face of the finished work, with its top 3 in. below the surface of the road surface. The new concrete was laid to cover the top of the board, and to connect up with the top 3 in. of the concrete already laid, thus forming an unbroken surface. Although very fine cracks have developed above the joints, no appreciable widening is noticeable, and as the cracks are too fine to permit water to percolate to the sub-grade the surface is not affected by cracks due to that cause.

REINFORCED CONCRETE IN SPAIN.

With few exceptions the designer of concrete buildings in Spain has failed, it would seem, to secure any intimate relationship between his material and his treatment of it. Although the use of reinforced concrete as a building material appears to be most extensive, and to embrace buildings of great diversity of form and function, the general impression that is gained from the pages of a very fully illustrated brôchure on reinforced concrete in Spain* is that only in the rarest cases does the design of the building owe anything to the material from which it is constructed. For the most part the designs are the result of that specious movement that spread over a large portion of Europe, fortunately never obtaining more than the most precarious foothold in England (if we lose much that is good through our insular position we also avoid much that is bad), known as "Nouveau Art." The chief characteristic of the style is a useless profusion of ill-designed curves. It may be asserted, by way of defence, that the Baroque architecture of both Rome and Spain has the same characteristic, but there is this difference in that the Baroque formed a natural development of the Renaissance, and, moreover, it was very intimately bound up with the Roman Church and its ritual, while the Nouveau Art was but a sporadic outburst of those desirous to create sensation. It had neither its roots in the past nor did it possess the virility to project into the future.

As has been indicated there are, however, exceptions among the illustrations reproduced in the brôchure, and perhaps the most notable of these is the staircase of a large store at Barcelona which is illustrated in *Fig.* 1. There is without doubt evidence of imagination and boldness of conception in the treatment of this staircase which makes it monumental. It is furthermore evident that the designer in creating his fine sweeping curves was throughout conscious of the material in which he worked, for there is about it a plasticity which is one of the distinctive qualities of concrete, and it is doubtful if any other medium would have yielded quite the same result.

Fig. 2 shows an interesting architectural composition executed in concrete. There is much to which exception might be taken by the purist, but the combination of the door and the window, and the relation of the voids to each other and to the surrounding detail is enterprising and displays vitality. The fault lies in the proportion of the entablature to the columns. The shafts appear too weak for the superimposed mass, which suffers from many unpleasant exaggerations that border on coarseness; particularly is the cymatium far too heavy.

It is often in quite small features that the influence of concrete is discernible by the observant; the fact that a certain feature could only have been carried out by means of that particular material rather than any other arrests the attention. Such examples are all too rare in England, where the architect seems too lethargic to inquire into the potentialities of this new method of building, or if he use it he is content to handle it as he would a stone covered steel structure. An admirable example of this spirit of adventure occurs in a house at Barcelona (*Fig.* 4). Seen as a whole the building is thoroughly ugly and is permeated with coarse detail and senseless curves; but in what other material could the projecting bay on the first floor have been so boldly achieved; so much glass, spanned with such grace? Only a material strong in both tension and compression can do such wonders.

The scope of the book is large, including warehouses, shops, garages, bridges, concrete boats, indeed, examples of every kind of use to which the material can be put are included with the exception of the small house or cottage. An extremely well-designed water tower is shown in *Fig.* 3. Here not only is the general conception good, but the details appear to be more refined than those which characterise so much

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* Published by Messrs. Construcciones y Pavimentos, Barcelona.

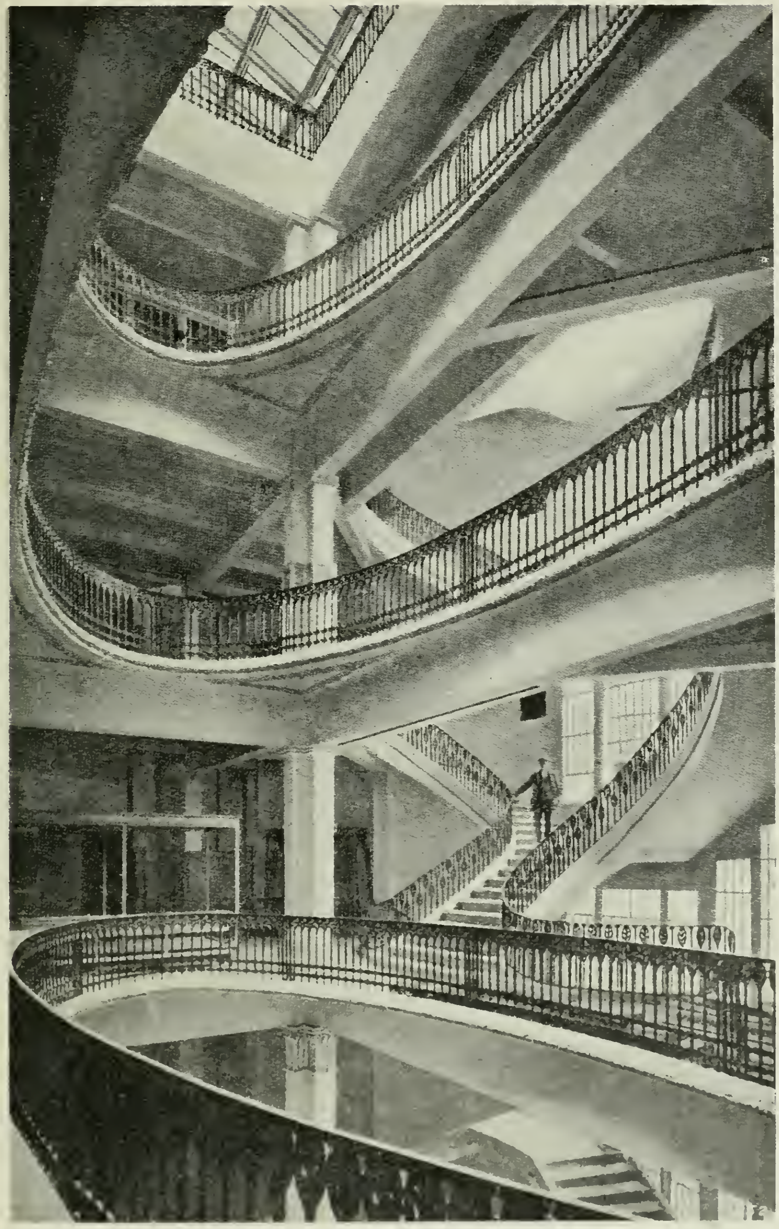


FIG. 1. STAIRCASE IN LARGE STORE AT BARCELONA.

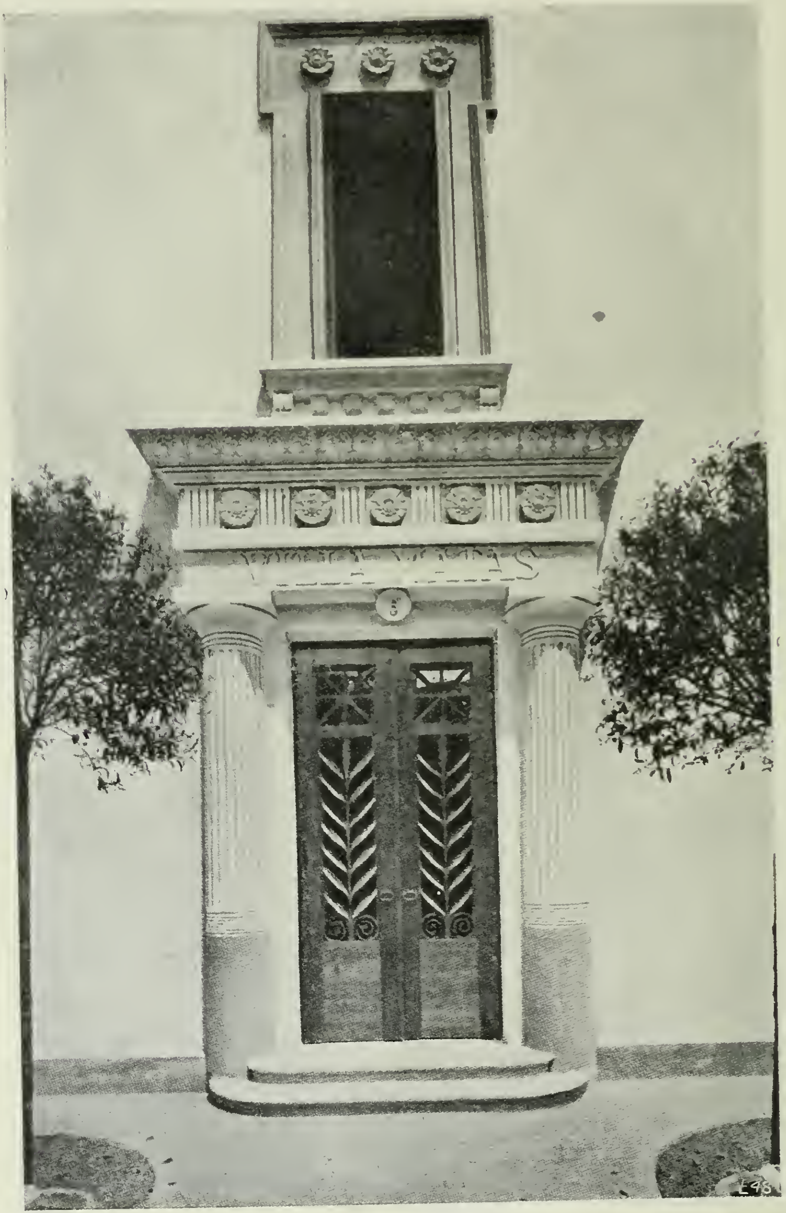


FIG. 2. ENTRANCE TO A CHALET IN SARIA.

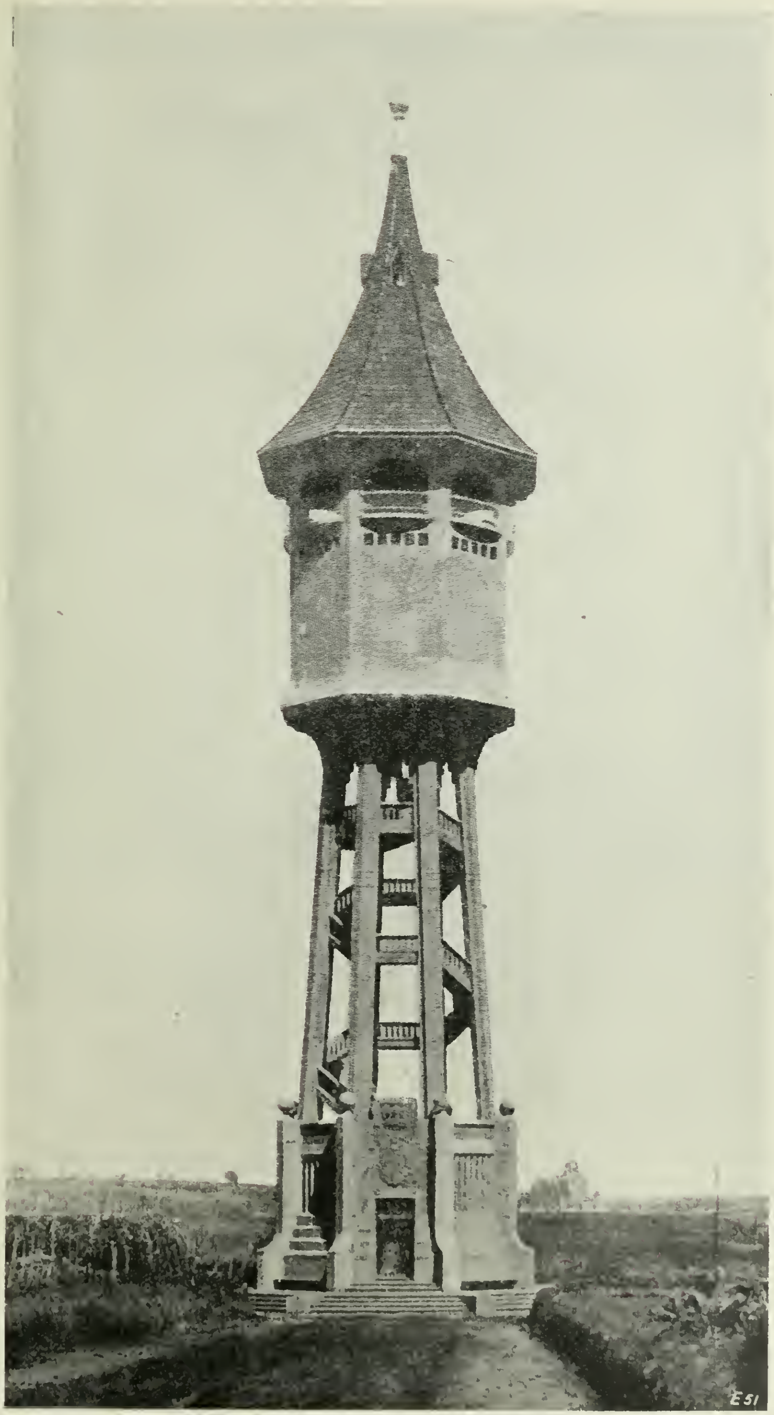


FIG. 3. A WATER TOWER AT SABADELL.

work in the book. There is little evidence of the influence of national Spanish architecture. Here and there the Moorish element is apparent, and in certain details, such as door canopies, metal work, grilles, garden ornament, the influences of the vernacular can be observed.

There is much justification for the assumption that reinforced concrete will eventually supersede steel work, except for roof construction, as a constructional system, and in order to display the advantages of the former the volume includes many photographs taken subsequent to an outbreak of fire in steel-framed buildings, showing their twisted and shrunken members crumpling the entire building in their death throes. Many reinforced concrete bridges are shown, and here the æsthetic superiority over steel work is patent; the component members, in many examples, have a sinuous grace that could be obtained in no other material, and the daring that is displayed provides a thrill of intellectual pleasure. Compared with steel work, which is mundane and often oppressive, the light concrete span appears romantic and capable of such infinite development and refinement.

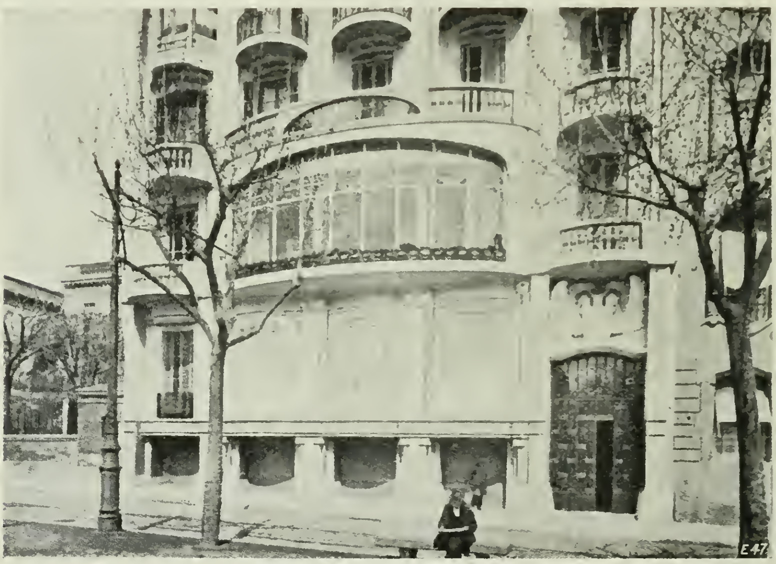


Fig. 4. A House at Barcelona.

The text of the volume is short; the first three sections deal with reinforced concrete in a general way and its development in Spain; these are followed by a chapter on the Architecture of Reinforced Concrete. In this chapter, however, the writer shows that he is alive to the new conditions arising from the use of the material and that the best results will not be obtained by working along the lines that were applicable to other materials. The more this consciousness is awakened the better will be the result whether the building be in Spain or in England, in America or in Germany.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete, the articles being prepared by Messrs. Andrews and Beaumont, Patent Agents, of 204–6 Bank Chambers, 29 Southampton Buildings, W.C.2. The last article appeared in our issue of December, 1920.—Ed.

Concrete Moulds.—*No.* 151,692. *John Woolcock and William John Stewart, 42 Albemarle Street, London, W.1. Accepted September 20/20.*—This invention consists in a method of moulding concrete products by the employment of rubber or material having similar properties for the moulding surfaces, according to which the reduction in the thickness of the rubber under the tension of withdrawal or the small determined contraction of a core or other part in the absence of supporting means is utilised for obtaining sufficient clearance to permit separation of the moulding and moulded surfaces by parallel or sliding movement without damage thereto.

Fig. 2

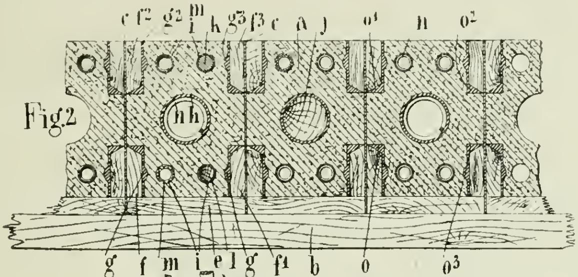


Fig. 1

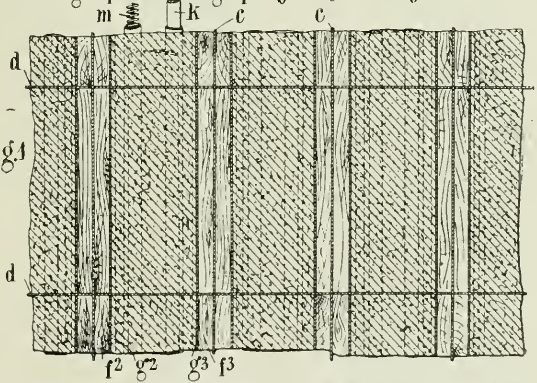
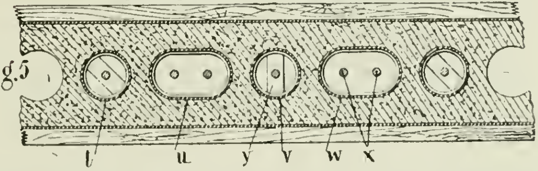


Fig. 5



Upon the moulding floor *b* there is erected a series of longitudinal partition plates *c* of length sufficient to accommodate any convenient number, and between these are inserted transverse partitions *d* formed of a continuous series of short division plates inserted between the longitudinal partitions *c*, the whole being retained in position by the bottom pallets which correspond in length with the plates *c*.

Running longitudinally of the compartments along the bottom angles are inserted filling blocks *f*, f^1 faced with a veneer *g*, g^1 of rubber, and in the upper corners of the compartments similar filling blocks f^2, f^3, faced in the same manner at g^2, g^3, are also inserted, the filling blocks being attached to the partitions *c*.

To form the cavities in the blocks, central cores *h* and additional cores *i* above and below the central cores are carried upon suitable supports, the cores being all formed of rubber tubes supported upon wooden or metal rods *j*, *k*, and *l* or upon helical spring members *m* or *n*.

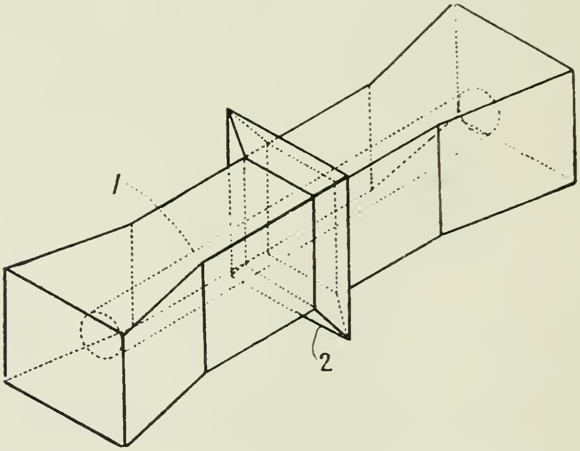
As soon as the concrete mixture has been filled into the moulds and the initial set has occurred, the filling members such as *j*, *k*, *l*, *m* or *n* may be immediately withdrawn and the partition plates removed from all accessible portions of the collection of blocks.

The exterior blocks are then easily taken away by manipulation of the bottom pallets or members *e*, and as soon as a block is separated and in a sufficiently dried condition, the corner filling blocks f, f^1, f^2 and f^3, together with the central and smaller rubber cores *h* and *i* may be withdrawn, each block remaining upon its supporting bottom member *e* until it is sufficiently matured for handling and stacking.

Fig. 5 shows the application of the invention to the formation of hollow concrete walls. In this case the rubber cores *t* or *u* are made in lengths sufficient for a day's operations and are supported upon suitable hollow filling members *v*, *w*, which may be positioned from rods *x* engaging cross pieces *y* at the ends of the fillings. Where a rigid filling is employed, these may be drawn upwards upon the rod while the concrete is still wet without difficulty, the rubber being left for removal at a later stage, or the rubber may be supported upon helical filling which may be withdrawn in the most convenient manner.

Concrete Wall Ties.—*No.* 151,755. *Alexander Hardie, Ashgrove, Bo'ness, Linlithgowshire. Accepted October* 7/20.—The present invention consists in a wall tie composed of water-proofed cement or concrete provided with a metallic core for reinforcement *l* and dovetailed at each end for engagement with counterpart pockets in the walls to be tied, the neck of the tie being formed with a ridge *2* for preventing the flow of water along the outer surface.

In practice the dovetailed ends are dipped in bituminous material prior to their insertion into the pockets.



Concrete Columns.—*No.* 151,765. *Alexander Hardie, Ashgrove, Bo'ness, Linlithgowshire. Accepted October* 7/20.—This invention consists in an improved column comprising a superposed series of one-piece hollow concrete blocks *1*, the bore of each of which is formed with longitudinal dovetail grooves *2*, the grooves being uninterrupted from end to end and a core of concrete agglomerate inserted into the bore in fluid state, the arrangement being such that the core, when solidified, is in dovetail relation with the blocks whereby the blocks are securely bound together.

Metallic rods *4* may be inserted into the core as shown for reinforcement, and rods *5* may also be inserted into the blocks.

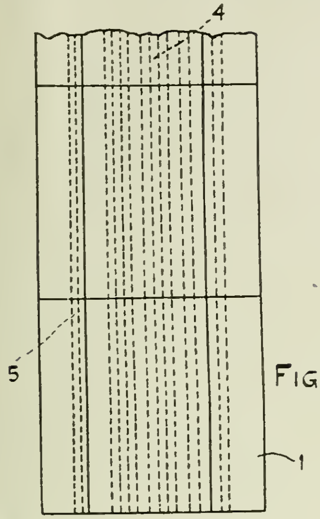


FIG. 1.

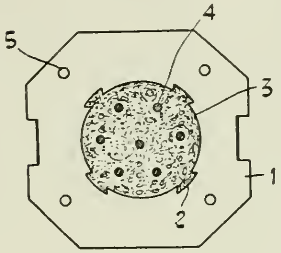


FIG. 2.

Metal Forms for Concrete Cottages.—*No.* 152,130. *Edward Dillon O'Grady Clarke,* 33 *Courtfield Gardens, South Kensington, London. Accepted October* 11/20.—This invention comprises an improved mould made up of several steel sheets connected together, during the construction of the concrete wall and the like in situ, by means of the special hinge attachments.

The mould is built up of vertically disposed and adjoining plates *1* and *2*, which

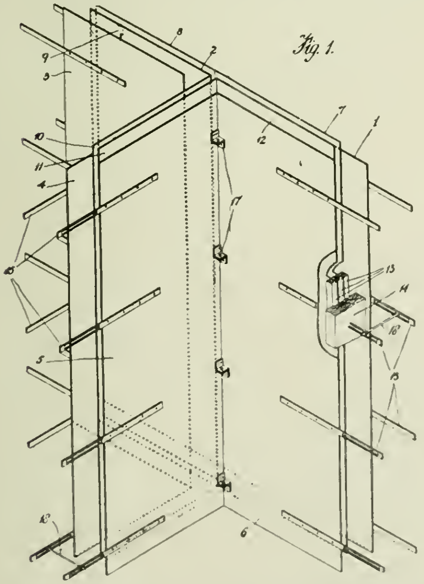


Fig. 1.

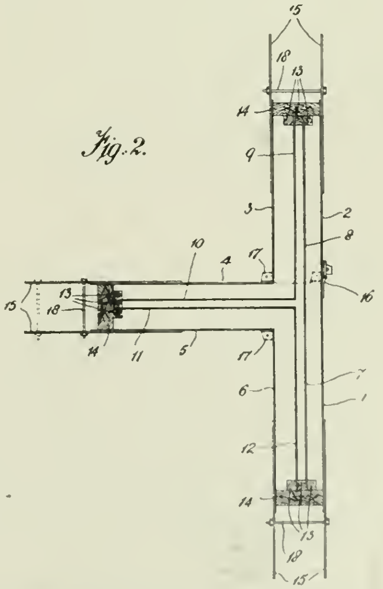


Fig. 2.

constitute the front wall plates of the mould, and vertically disposed and adjoining plates *3, 4,* and *5, 6* arranged at right angles to one another, which constitute the inner wall plates of said mould. The outer wall plates *1* and *2* are connected together, in a vertical direction, by a series of hinge attachments *16*, whilst the inner wall plates *3* and *6* are connected to the inner wall plates *4* and *5*, and at right angles thereto, by a series of pairs of angle attachments *17*. The members of each pair of attachments *17* being arranged on the wall plates *3* and *6*, and *4* and *5*, respectively, the above described arrangement of plates giving, as shown in full lines, a T-shaped three-way mould for a solid wall.

These outer and inner plates *1* to *6* are, at the sides remote from the before-mentioned hinge and the angle attachments, provided with a series of horizontal and longitudinally extending slotted bars or stretchers *15* riveted thereto, by means of which, and bolts *18* passed through the slots in oppositely disposed stretchers, additional outer and inner wall plates can be adjustably secured to the mould.

To form a cavity wall, use is made of an inner mould, which mould is constituted by vertically disposed and adjoining outer plates *7* and *8*, and vertically disposed adjoining inner plates *9*, *10*, and *11*, *12*, the plates *10* and *11* being arranged at right angles to the plates *9* and *12*, giving a T-shaped or three-way inner mould; and the ends of said three-way inner mould are closed and sided with wooden blocks *13* to form key-ways in the concrete wall, these blocks *13* butting against other wooden blocks *14*, which blocks *14* serve as distance pieces to and between the ends of the plates forming the outer mould.

Pre-cast Concrete Floor Beams.—*No.* 152,160. *W. J. Stewart and J. Woolcock, 12 Berkeley Street, W.1. Dated August* 12/19.—According to this invention pre-cast beam members of insufficient length to bridge completely the distance between the supporting abutments are arranged side by side with alternate members supported upon opposite abutments by one of their ends, each member being adapted to support the free end of the next adjacent or subsequently positioned member and the whole being incorporated into the floor by grouting and in situ work extending from the free ends to the adjacent abutments.

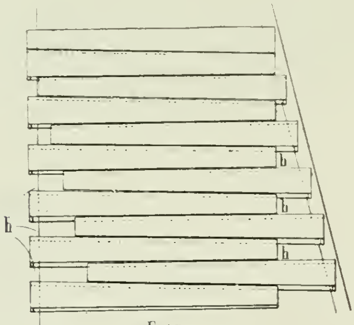


Fig 7

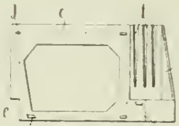


Fig 4

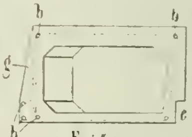


Fig 5

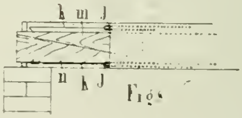


Fig 6

The beams are preferably tapered and are constructed of a length which will not exceed the shortest span upon which it is desired to employ them as shown in *Fig.* 7, and they are preferably of a length which is about 20 per cent. less than the span over which they will generally be employed, the structure for which they are required being as far as possible so designed that one length of beam will be sufficient for covering all the floors of the structure with varying lengths of in situ extension.

Along the bottom edges the beams are provided upon one side with a projecting parallel ledge *d*, preferably reinforced as shown, and the other side of the beam which may be called the inner side is provided with a complementary recess *e* adapted to accommodate a projecting part of the ledge *d* upon the outer surface of the adjacent beam.

The beams in addition to the ledges are also provided upon their outer sides with a series of projecting contacting surfaces *f* along the upper edge of the beam, projecting about one half of an inch above the surface of the remainder of the side, so that when the inner side of one beam is pushed as close as possible against the outer side of the next, there is provided a series of connected grout-spaces reaching from the top of the ledge to the top of the beam.

At the wide ends which rest upon the walls or other abutments, the ledges *d* are strengthened by webs *g*, and the beams are made in pairs, that is right hand and left hand.

Building Blocks for Cavity Walls.—*No.* 152,405. *James Carter, Institute Buildings, Windermere, Westmorland, and William Bennet, College Road, Windermere, Westmorland. Accepted October* 11/20.—The improved building blocks constructed in accordance with this invention are characterised in that the interior face has a panelled surface with a longitudinal mid-rib, and cross ribs at right angles thereto, the recesses between the ribs having a plane surface, and in that the ends of the ribs at the edges of the blocks are left exposed, so that such ribs when the blocks are set up shall find their exact partners and be co-extensive with the ribs on adjacent blocks, whereby the accurate setting of the blocks by a sense of touch is facilitated. In a modification, the cross ribs instead of being at right angles to the longitudinal one, may be arranged diagonally with respect thereto and arranged to cross one another, the diagonal ribs being likewise left exposed at the ends, so that when the blocks are set up, such ribs shall find their exact partners and be co-extensive with the ribs on adjacent blocks for the purpose of facilitating an accurate setting by a sense of touch.

The blocks are moulded so as to have a plane front surface *A* A^1 and a recessed or panelled rear surface *B*. This recessed surface *B* is made with horizontal or cross ribs *C*, and the hollows or recesses *B* between the ribs have plane bottoms, such ribs and recesses being adapted to register with similar ribs and recesses in adjacent bricks or blocks, so that a wall built up of these bricks or blocks will present on one face a plurality of ribs *C*, *D* crossing each other at right angles with rectangular recesses *B* between the ribs, the depth of the recesses being about half the thickness of each block.

Fig. 1.

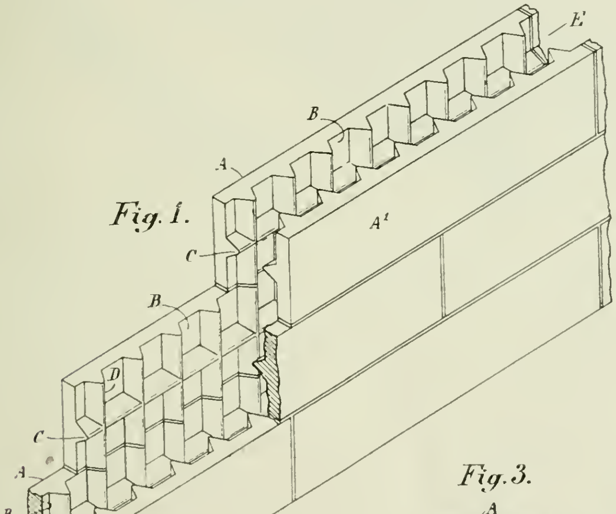


Fig. 3.

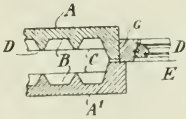


Fig. 4.

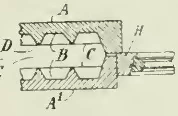


Fig. 3 shows the blocks arranged with a jamb or rebate facing inwardly, so that a wood window frame *G* can be applied from the inside; and *Fig.* 4 shows the blocks arranged with a jamb or rebate *H* facing outwardly, so that the wood window frame *H* can be applied from the outside of the wall.

Concrete Block Walls.—*No.* 152,776. *Charles Marques,* 11 *Osborne Road, Forest Gate, E.7. Accepted October* 22/20.—According to this invention a reinforced concrete wall of the block type is provided with means for holding up at any required level a mass of new concrete or wall filling to form beams or girdering within the face of the wall.

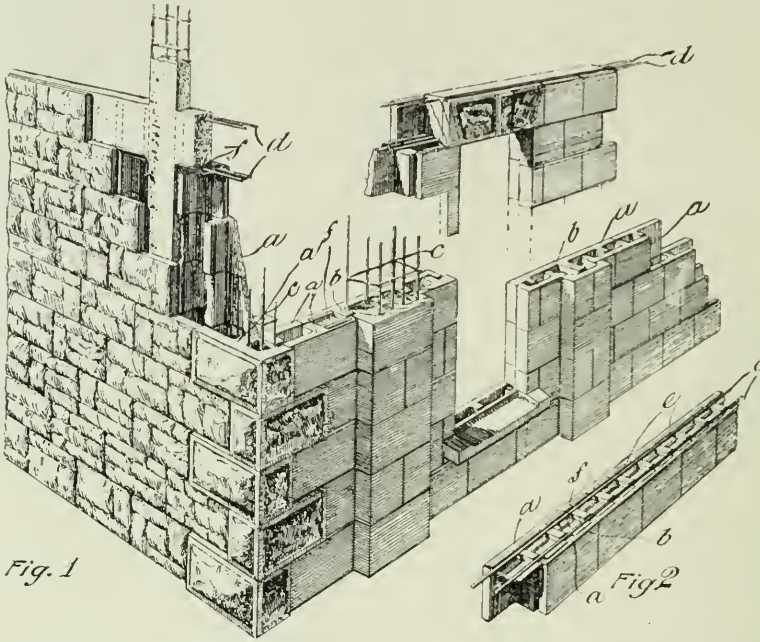
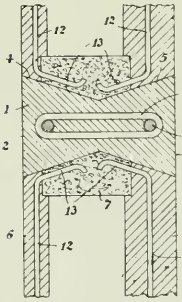


Fig. 1 Fig 2

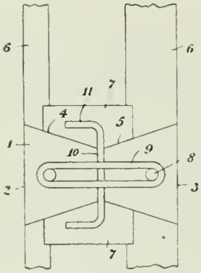
The structure is made up of oppositely opposed blocks *a, a* formed with one or more vertical webs *b, b* having reinforcements *d, d* between the blocks *a, a.*



The horizontal reinforcements *d, d* extend along the length of the wall and lie in grooves *e, e* formed across the webs *b, b* of the blocks *a, a. f, f* are metal plates adapted to bridge the spaces between two oppositely opposed blocks and hold up concrete about the horizontal reinforcements *d, d.*

The plates need not be dished as illustrated but may be flat, and in the latter case no grooves would be formed in the webs *b, b,* the reinforcements *d, d* simply resting on the said webs.

In a modified construction each block is formed with an inwardly projecting ledge or shelf arranged that when the oppositely opposed blocks are placed in position the ledges abut against one another and form a bed for the concrete.



Concrete Framework Buildings.—*No.* 152, 888. *William Emanuel Hale and Leslie Hugh Hale,* 63 *Belvidere Road, Wallasey, Cheshire. Accepted October* 28/20.—According to this invention a framework is provided comprising a plurality of precast concrete vertical units which engage precast inner and outer wall or like slabs in such manner as to leave a cavity between, while the parts are secured by grouting across the ends of the cavities adjacent to the framework units. The framework and slab units are so shaped that they can be keyed together by a grouting applied in this manner. It will be seen that these units are not of the "block" type, as the vertical units are rather of the nature of pillars.

The framework vertical units consist of precast concrete pillars *1* having parallel inner and outer sides *2* and *3*, but the lateral sides are shaped so as to key with the grouting, preferably by forming said lateral sides as two surfaces *4* and *5* with a re-entrant angle in the middle. Each side thus slopes inwardly from say the front edge and then half-way across slopes outwardly towards the back edge.

The wall slabs *6* are correspondingly shaped at their ends, e.g. so as to slope outwardly when proceeding inwards from the edge. The inner face of the slab (next the wall cavity) is cut away for a short distance and situ concrete or cement grouting *7* is then employed at this point (e.g. with the aid of temporary shuttering) to key the ends of the slabs to the lateral undercut faces of the foundation members.

The framework may be reinforced by round steel bars *8* with suitable links *9* or wire binding and reinforcing bars *10* may be passed transversely through the pillars and their ends bent at right angles so that the bent ends *11* lie within the grouting. In some cases the lateral faces may be roughened or corrugated to ensure better adhesion.

Ties for Hollow Concrete Walls.—*No.* 153,102. *Thomas Arthur Locan,* 323 *High Holborn, and David Eustace Landale,* 34 *Fenchurch Street, London. Accepted November* 2/20.—This invention relates to concrete slab or block structures of the hollow walled type, wherein the walls are maintained parallel and at the proper distance apart by means of U-shaped distance-pieces having parallel limbs bearing against the inner, opposed faces of the walls.

Fig 1

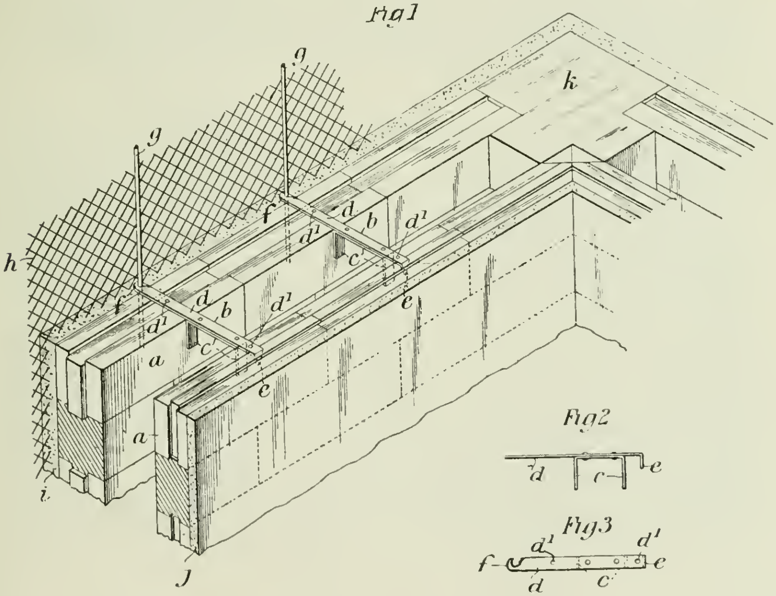


Fig 2

Fig 3

The object of this invention is to provide improved means for tying together the walls of a concrete slab or block structure, and consists in providing such a structure with U-shaped distance pieces each combined with a tie member; one end of each engages in a concrete block or slab of one of the walls, while the other end of the tie member is extended through the opposite wall to engage with an outer shield or shield of reinforced concrete or the like, so applied as to become an integral part of the wall.

The slabs or blocks of concrete are built up in a series of courses in the ordinary way so as to form inner and outer walls. The devices *b* for maintaining the two walls parallel and at the proper distance apart, comprise the U-shaped strip *c* secured to the horizontal bar *d* projecting, on either side of the U-shaped strip *c*, one of the projecting ends being bent downwards as indicated at *a* so as to form a hook, whilst the other end is formed as a claw *f*. d^1 are nail holes in the bar *d*.

As the courses of the blocks or slabs are built up in two walls, the connecting devices *b* are applied so that the bars *d* rest upon the blocks and the legs of the U-shaped strips *c* bear against the inner faces of the opposing courses of blocks, thus determining the distance apart at which the two walls are built and the parallelism of the two walls. The down-turned end *e* of each bar *d* is driven into the upper face of the blocks or slabs supporting them as indicated in *Fig.* 1, and the other claw-like end of the strip projects beyond the outer faces of the outer wall and is designed to engage the upright rods *g* around which they can be clinched, the bar *d* being nailed to the two walls by nails driven through the holes d^1.

Concrete Glazing Bars.—*No.* 153,800. *Charles Edward Winter,* 19 *Harlescott Road, Waverley Park, London, S.E.*18. *Accepted November* 18/20.—Astragals, glazing bars and the like constructed in accordance with this invention comprise in combination a sheath of sheet material, a reinforced concrete filling, and one or more longitudinal water-channels.

The beam comprises an outer metal sheath *a, Fig.* 1, provided with a reinforced concrete filling *b* which completely occupies the hollow interior of the sheath.

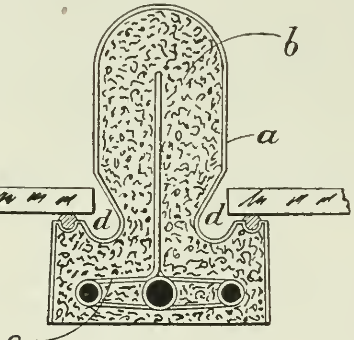


Fig. 1.

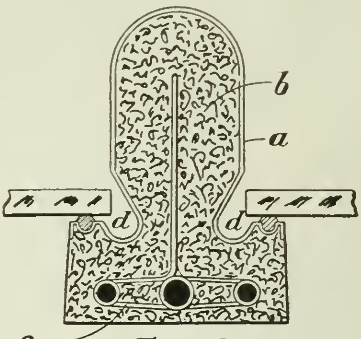


Fig. 2.

The compression area of the beam in question is augmented by increasing the width of the upper part of the beam beyond the limits set by the water channels *d*, an advantage not easy to provide in ordinary glazing bars owing to the difficulty of withdrawing the bar from the mould. Further, compression rods in the upper part of the beam may be dispensed with, as the sheath *a* provides sufficient strength in substitution.

In the modification shown in *Fig.* 2 the wings of the sheath are terminated just beyond the water channels, and the glazing bar is completed by an uncovered base portion.

Preferably, in both modifications, the sides of the base portion are tapered slightly to permit of easy withdrawal from the mould or holder.

The sheath is preferably formed of non-corroding sheet metal, but iron may be used if desired, the exterior being suitably covered with paint.

Seaham Harbour Concrete Road.—An experimental length of concrete road is to be laid down by the Seaham Harbour, Durham Urban District Council. The surveyor, Mr. F. E. Boaz, has been instructed to do the work immediately above Seaham Colliery Station.

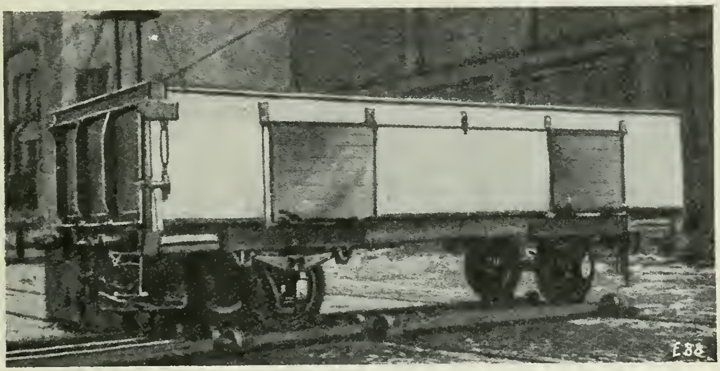
Reinforced Concrete Roadwork in Middlesbrough.—Middlesbrough Tramways Committee have accepted the tender of Messrs. Coxhead & Co., Middlesbrough, at £6,837, for paving Grange Road in reinforced concrete.

CONCRETE RAILWAY WAGONS.

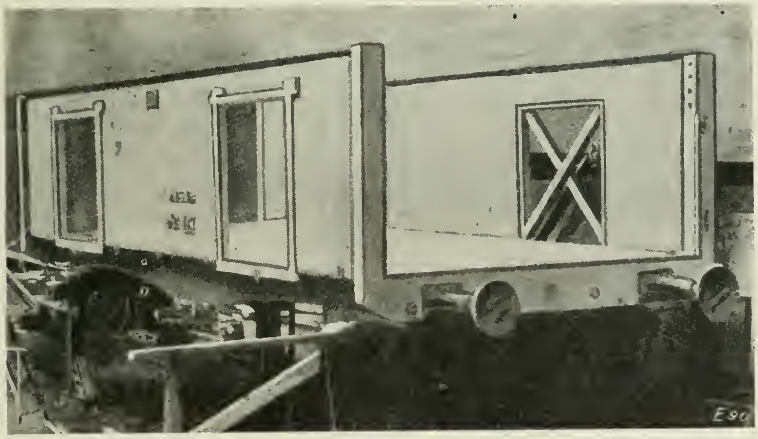
The following particulars and illustrations have been reproduced from "Beton u. Eisen."—Ed.

The exceptional scarcity of iron and timber in Hungary has led to the construction of railway wagons in reinforced concrete and these have met with considerable success.

The authorities concerned laid down the following conditions, which were all complied with :—



The Austrian Ke Type.



The Wagon after removal of Shuttering.

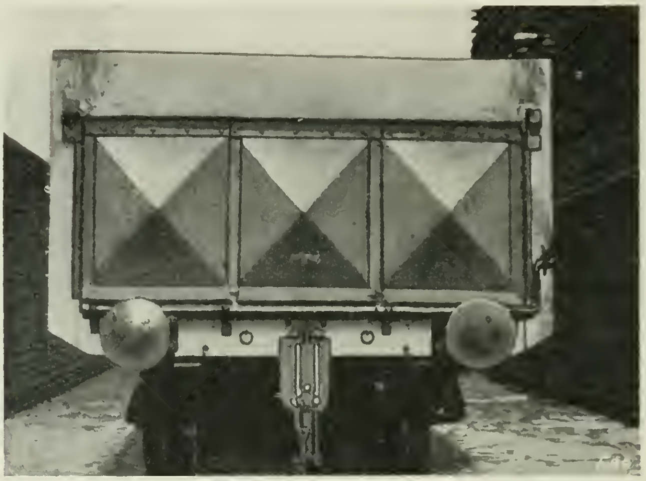
(i) The concrete wagons must be of the same size and shape as the wagons ordinarily in use.

(ii) Any interchangeable parts must be completely interchangeable, this condition to apply to wheels, hauling gear, buffers and couplings.

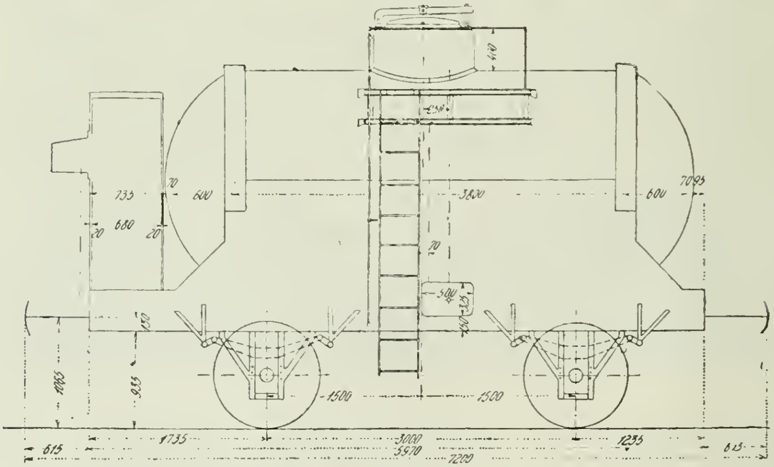
(iii) The minimum weight of iron to be used with a maximum load-carrying capacity, but the weight per axle must not exceed 15 tons nor the total weight when loaded 30 tons.

As built, each wagon has all the fittings of the standard *Kmn* Coal-trucks (without brakes) of the Hungarian State Railway. The side walls have the same resistance to pressure as these standard wagons. The under frame consists of two outer and two inner longitudinal girders, two cross girders at front and back and a number of supplementary ties. All these are arranged to form a monolithic structure.

The front and back openings of reinforced concrete are replaceable and the side openings, edges, sills and lintels are all protected by angle iron. The various metallic parts are screwed into the concrete, the female parts of the screws being cast in the concrete. The concrete for the under carriage was composed of 1 part of cement, 1 part of gravel, and 2 parts of sand; that for the sides of 1 part of cement, 2 parts of gravel, and 2 parts of sand. The iron rods used for the reinforcement were 0·16–0·72 in. diameter.



Front View of Kmn Type.



A Concrete Oil Tank.

Each wagon weighed 11½ tons when empty and 18½ tons when filled with coal, but if a highly porous aggregate were used the tare of the wagon could be reduced to 9 tons. As the specific gravity of concrete is four or five times that of wood, it seems inevitable that concrete wagons should be heavier than those made of timber. The advantage of concrete lies in the much smaller quantity of iron required and in the complete saving of timber at a time when iron and timber are both scarce.

A wagon of a slightly different type—being the standard Austrian (*Ke*) type and about 3 ft. longer than the Hungarian ones—was built by W. Custer at the Simmeringer Wagon Works, Vienna. This wagon was made to resemble the standard trucks as closely as possible, but the mode of fastening the wheel brackets to the under carriage, the fastening of the couplings and the arrangements for reducing damage in the event of a collision are different. A door at one end is larger than in the Hungarian truck and the ironwork extends to the top. The Austrian wagon weighs about a ton more than the Hungarian one, but in future designs a reduction of weight will be made.

Three tank-trucks of 518, 666 and 925 cubic feet capacity were designed to be built of reinforced concrete. Such wagons require much more skill in design and construction as a small crack, which would be negligible in a coal-truck, would be very serious in an oil-tank, and eventually two tank-trucks, each of 925 cubic feet capacity, were built. It is too early to report adequately upon their durability, but up to the time of writing they are quite satisfactory.

THE MACQUARIE BRIDGE (*continued from page 222*).

The main trusses are 22 ft. deep between centres of chords and are spaced 23 ft. 6 in. apart centre to centre. The panel length of 12 ft. was fixed as being the greatest span which would permit of a rolled girder 24 ft. by 7½ in. by 100 lb. per foot run being used as a cross girder.

The deck slab is 6½ in. thick with a concrete wearing surface 2½ in. thick at the centre and ½ in. at sides reinforced with round bars.

The deck on the reinforced concrete beam spans is 9 in. thick with a covering of tarred metal. The beams are 2 ft. wide and the depth from the top of the slab to the underside of girder is 3 ft. The beam reinforcement consists of twelve 1¼ in. diameter rods bent up at various points to resist the shearing stresses which are also further provided for by vertical stirrups.

The bridge was designed for a live load of 100 lb. per square foot uniformly distributed for the carriage and footway and for a 24-ton lorry road, the weights on the rear axle being taken as 16 tons; the wheel base assumed for the lorry was 12 ft. by 6 ft. The trusses were further designed for a moving load of 9 tons per panel at such points as to give a maximum stress in any member.

The work was divided up into three contracts. Contracts No. 1 and 3 were carried out by the State Monier Pipe and Reinforced Concrete Works, and No. 2 by the Government Dockyards at Walsh Island, Newcastle, at a total cost of £23,326.

The structure was designed by the officers of the Public Works Department under Mr. R. E. Jones, M.Inst.C.E., whilst the work of construction was carried out under the supervision of Mr. Morrice, District Supervising Engineer, acting under Mr. Percy Allan, M.Inst.C.E., M.Am.Soc.C.E., Chief Engineer for National and Local Government Department.

CONCRETE

CONCRETE IN THEORY AND PRACTICE.

A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.

REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—Ed.

CHAPTER VI.

Materials.

73. Having now discussed the general theory of design as far as is possible in a simple description as opposed to a specialist's treatise, we are in a position to describe more carefully and intelligently the materials used and some of the properties of the concrete.

We will first consider the materials.

CONCRETE.

74. *Voids.* Concrete is to be considered as a mass of stones having certain spaces or *voids* between them.

These voids are then filled with sand, which in turn contains voids.

The voids in sand are not so obvious as those between the stones, but in fact there is often about the same proportion of voids in sand as in the stone.

The voids in the sand are finally to be filled with cement for the mixture or concrete to be quite solid and dense.

Suppose, for example, the stones contain 40 per cent. voids, then if the sand could be inserted between them without separating them, obviously the sand volume should be 40 per cent. of the stone volume (both volumes being measured to include solid and void in natural proportion). In practice, it is impossible to get the sand to fill the stone voids without some sand particles also remaining between the stones where they would otherwise touch, and generally it is necessary to add about 10 per cent. (depending on size of particles chiefly) more than the void contents.

Thus a stone with 40 per cent. void needs in practice 40 per cent. + 10 per cent. = 50 per cent. sand.

The same applies to the sand voids. If the sand contains 30 per cent. voids, then if the cement could be made to fill the voids without separating the sand particles, 30 per cent. of the sand volume should be the cement contents. In practice, a greater volume is required, because the cement, besides filling the voids, also forms an adhesive film round the surface of sand and stone particles, and in practice about 20 per cent. more cement is required, so that roughly 30 per cent. + 20 per cent. = 50 per cent. of the sand = cement required.

It will be seen that if the stone needs 50 per cent. sand, and the sand needs 50 per cent. cement to fill all the voids, then a concrete of 4 parts stone, 2 parts sand, 1 part cement practically meets the requirements of a dense solid concrete.

If the stone contains less voids, less sand and cement is needed, and if the sand contains less voids, less cement is needed, and the correct proportions can easily be estimated when the voids are known. In practice, the voids are easily determined by the simple process of weighing a given volume of sand or stone. It may be taken that the solid material in nearly all common stones weighs almost exactly 160 lb. a cu. ft. If, therefore, a sample of broken stone including voids weighs only 106 lb., the solid material will be $\frac{106}{160} = 60\%$ and the voids $100 - 60 = 40\%$.

It will be found in practice that angular stone has a higher void percentage than rounded stones, and therefore needs more *mortar* (sand plus cement) to fill its voids.

When the voids are not completely filled the concrete is known as *hungry*. Not only is the strength impaired, but the waterproof properties, and the protection of the reinforcement from corrosion is also seriously reduced.

When measuring the void contents in sand certain interesting facts exist which bear on the problem.

If a box containing dry sand has water poured on it, the sand will settle so that it no longer fills the box. If it is then tipped out, it will be found to be more than is required to fill the box. In the first case, the effect of water was to reduce the friction between the particles and cause them to settle down closely together, while in the last case, where the water is not actually poured on, but only the water adhering to the surface is left, the surface tension prevents movement of the particles, just as wet sand will make a castle at the sea-side while dry sand refuses to stand.

For the purpose of measuring the voids, the densest condition should be chosen, because in ordinary concrete there is enough water to allow of free movement of the particles.

A good and ready test of the success attending the proportioning of concrete is clearly the weight of a cube of concrete, since the difference between the weight of concrete per cubic feet and 160 lb. indicates the amount of voids left unfilled. This test applies to cubes made of granite ballast, quartz, shingle and sand, etc. In the case of broken brick of a porous nature, it is of course impossible to make so heavy a concrete, as the voids in the brick itself cannot readily be filled.

With dense materials, a cube often weighs 146 lb. a cubic foot, indicating about 10 per cent. voids in the finished concrete. Many experiments have clearly demonstrated that the heavier cube is also the stronger, and the reason should be obvious from what has been said.

It is impossible at present to make a concrete entirely without voids, because when the concrete is mixed with water in the mixing, this water represents a considerable volume. Although part of this water enters into chemical combination with the cement, the larger part does not, but subsequently evaporates and is replaced by air. It becomes clear from this that an excess of water in concrete reduces the strength because the concrete will be less dense. This is well understood by cement-testers who will spend time in ascertaining for any sample of cement the minimum proportion of water which can be used, and will often secure tests exceeding by 20 per cent. those made with a more liberal supply of water.

Excess of water has other disadvantages which will be referred to later.

75. *Cement Contents.* From the above it might be concluded that if the proportions have been so adjusted as to fill the voids in the manner indicated no advantage accrues from adding more cement.

This, however, is not so, as the following table of representative tests indicates.

Cement.	Sand.	Stone.	Crushing Strength.	
			1 month.	4 months.
1	2	4	1,500	2,250
1·2	2	4	1,650	2,475
1·5	2	4	1,800	2,700
2	2	4	1,950	2,925
neat cement.			5,000	7,500

These tests being of cylinders in preference to cubes for reasons to be stated later.

The reason why a greater cement content increases the strength of concrete, even when this is tested in compression, and even after all the voids seem to be filled as far as practicable lies in the nature of failure of a concrete cube in crushing.

As a rule the crushing takes place by the wedge-like action of the stones splitting the block laterally, dividing it up by vertical lines into several prisms liable to buckle. This action is resisted by the tensile strength of the concrete.

Now the tensile strength across any concrete fracture consists partly of the adhesion of cement to stone particles in the section, and partly by the tensile strength of cement to cement in the interstices between the stones. The greater the cement contents, the greater proportion of area at any section is cement and not stone, and therefore the greater the tensile strength.

As has just been mentioned, the crushing strength is really limited by the tensile strength, and therefore it happens that there is an almost constant ratio between the compressive and tensile strength of all brittle materials, of which concrete is one. In the case of concrete this ratio is about ten to one, and if the table given above is divided by ten, it gives average values of tensile strengths.

Obituary.

THE LATE FRANCOIS HENNEBIQUE.

We deeply regret to have to announce the death of M. Francois Hennebique of Paris, which took place last month. As is well known to our readers, Francois Hennebique was one of the world's pioneers in reinforced concrete, and it was his studies and investigations which have given to the world the special form of construction known as *Ferro-Concrete*, a system which he had worked out in all its details in order to make it applicable to any kind of construction. The special features of his system have been frequently illustrated in these pages, and readers are familiar with many of the structures erected under it.

Francois Hennebique was born at Neuville St. Waast (Pas de Calais) in 1842, and early in life he developed a special bent for the mechanical arts. After years of close theoretical study and practical work he established himself as a contractor for public works, and soon found himself entrusted with every kind of construction, large public buildings, bridges, viaducts, etc. His early studies in stereotomy and architecture also enabled him to apply his special knowledge to the restoration of a number of historic monuments, among them the churches of Notre Dame and St. Courtrai.

In spite of his numerous activities he found time to study concrete and its effects in combination with rods of steel or iron. It was only after exhaustive study and investigation that he finally made his system known to the public in 1892, from which time onwards it has developed to such an extent that it is now known and used in all parts of the world.

CEMENT NOTES.

By Our Special Contributor.

Calcium-Aluminate Cements.

In the January issue of this Journal, the suggestion was made in these Notes that rapidity of hardening would be one of the directions in which the cement of the future might be an improvement upon the current material. A remarkable development in this direction is now revealed in some tests made by the U.S. Bureau of Standards with calcium-aluminate cements. The main constituents of these cements are lime and alumina chemically combined, although silica up to 10 per cent. and iron oxide up to 3 per cent. may apparently be present without disadvantage. Calcium-aluminate cements differ from Portland Cements in containing alumina as the second predominating constituent instead of silica.

Crushing strengths of 3,000 lb. per sq. in. in 24 hours have been obtained from a concrete containing 1 part calcium-aluminate cement to 6 parts aggregate, this being more than the strength expected from a Portland Cement concrete at 28 days. Similarly a 1 : 3 : 9 gravel concrete with calcium-aluminate cement gave a result of 3,415 lb. at 28 days and 4,445 lb. at 1 year.

These are startling results and subject to possessing the necessary qualities of stability and resistance to atmospheric conditions, the calcium-aluminate cements may have an important bearing upon the constructional work of the future.

It should be understood that these results are the results of laboratory experiments, and the manufacture of calcium-aluminate cements has apparently not yet been attempted on a practical scale. Hitherto, cements with unusually high proportions of alumina have been regarded as suspect, especially for use under marine conditions, and it may be that calcium-aluminate cements will not stand the test of practical use. In the present stage, therefore, the tests reported are more of interest to the research worker than to the engineer, although they may suggest to the latter possibilities in connection with concrete which have previously been rejected as idle dreams.

Concrete Improvers.

There are differences of opinion as to the necessity or desirability of using any waterproofing agents with concrete. The view taken by cement manufacturers generally is that a good cement in the right proportion with a well-graded clean aggregate will yield a water-tight concrete, and the opinion of the manufacturer in this connection should carry much weight.

So far as is known the most authoritative pronouncement upon the subject is that by the American Bureau of Standards after an examination of forty waterproofing compounds. The report states :

" Portland cement mortar and concrete may be made practically water-tight or impermeable . . . to any hydrostatic head up to 40 feet, without the use of any of the so-called ' integral ' water-proofing materials, but in order to obtain such impermeable mortar or concrete, considerable care should be exercised in selecting good materials as aggregate and proportioning them in such a manner as to obtain a dense mixture.

" The addition of so-called ' integral ' water-proofing compounds will not compensate for lean mixtures, nor for poor materials, nor for poor workmanship in the fabrication of concrete. Since in practice the inert integral compounds (acting simply as void filling material) are added in such small quantities, they have very little or no effect on the permeability of the concrete. If the same care is taken in making the concrete impermeable without the addition of water-proofing materials as is ordinarily taken when waterproofing materials are added, an impermeable concrete can be obtained."

The object of this note is, however, not to discuss the merits of the water-proofing compounds on the market, but to call attention to what is considered a legitimate concrete " improver," viz. silicate of soda. This material is otherwise known as " water glass " and is retailed as a viscous liquid for egg preserving ; it is not a proprietary article.

Silicate of soda is fundamentally sound as an improver of concrete because it provides active silica which can combine with lime set free during the setting process of cement and thus form silicate of lime, which is one of the compounds contributing to the strength of cement. A convenient solution to use is obtained by mixing 1 lb. of silicate of soda with 1 gallon of water, and the solution can be applied with a watering-can fitted with a rose, or with a whitewash brush. Three applications at intervals of about two days usually yield the best result, but it should be understood that the treatment is essentially a surface treatment only and only efficacious in so far as the solution penetrates the concrete.

The following tests for tensile strength of briquettes of 1 sq. in. in section immersed in a solution of sodium silicate show the increased strength resulting from the treatment :—

7 days neat immersed in water . . .	590 lb. per sq. in.
7 days neat immersed in sodium silicate .	670 ,, ,, ,, ,,
7 days (3 sand, 1 cement) in water .	267 ,, ,, ,, ,,
7 days (3 sand, 1 cement) in sodium silicate	382 ,, ,, ,, ,,

As a surface hardener, silicate of soda is especially useful for the treatment of concrete floors to increase the resistance to wear and to enable traffic to be put on the floor at an earlier date than would otherwise be possible.

It is impracticable to mix silicate of soda with the water used for mixing the concrete, because it acts to some extent like carbonate of soda in causing the cement to set very rapidly.

Rough and Ready Tests for Cement.

The need is often felt by Clerks of Works and Contractors' foremen for simple tests of cement which they could apply themselves and so avoid the delay and expense associated with experts' tests. This need becomes particularly acute when a batch of concrete fails to harden or when a range of cement-jointed pipes does not stand the water test. In such cases, the user generally regards the cement as the unknown factor and is inclined to blame it, although if a simple test were available, the responsibility could soon be placed in the right quarter.

In spite of the absence of official tests of this nature, it is frequently observed that attempts are made to test the quality of cement without having recourse to an expert. The *bottle test* is one method adopted, consisting of filling a glass bottle or jar with cement paste and observing whether the cement on setting contracts and becomes loose, or expands and cracks the glass. This is quite unreliable as a test and must be unreservedly condemned. If the cement does become loose in the glass vessel, it is merely an indication that too much water has been mixed with the cement, while if the glass cracks the cause may possibly be expansion of the cement, but is far more likely to be the difference in the rate of expansion and contraction of glass and cement with changes of temperature. Many have had the experience of retaining for six months a dozen or more glass vessels filled with different cements and finding the whole of them cracked on one day owing to a sudden change in temperature.

The *immediate immersion* test is another attempt at discovering the qualities of a cement in a few hours. This test consists in immersing a pat of cement paste in water immediately after mixing and observing in twenty-four hours whether the pat is soft, cracked or deformed. All that need be said of this test is that it has been considered by the Engineering Standards Committee and expressly excluded as depending upon setting time more than any other factor.

A third test, and the only one that is worthy of consideration, is that of mixing the cement with water and observing the setting and hardening. As frequently carried out, this test is misleading, and to provide useful information it must be conducted as follows :—

About 1 lb. of cement is laid on a sheet of non-porous material (slate, glass, or iron, but not brick, tile, or wood) and mixed with just sufficient water to make a stiff paste. If the mixture is at all "sloppy" more cement should be added to stiffen it and care must be taken to get a thorough mixture of cement and water. The paste is then formed into a square or circular cake about an inch thick and put in a place where it will remain at an even temperature and out of the influence of draughts. A good plan is to cover the pat with an inverted box. The pat is then tested with the finger-nail or pencil point every ten minutes for the first hour and thereafter every half-hour, to ascertain the progress of setting, while if it is kept a day or two a good idea will be obtained of the hardening qualities. It is essential that the test should be made in a building at a temperature of about 60° F. and the pat maintained within 5° of this temperature throughout, otherwise the result will be misleading.

If when the pat is hard it is immersed in water and boiled for a few hours and then found to be free from any pronounced cracks or marking, it will be a reasonable conclusion that the cement is sound.

This test, if conducted with care, should provide evidence of the setting and hardening qualities and soundness of a cement. If the results are not satisfactory to the user he should inform the cement manufacturers or submit a sample to a recognised cement expert.

A parallel test under similar conditions of a mixture of the cement and the aggregate to be used with it can also be made, and if the neat pat is good while the concrete pat has failed to harden, there is evidence that the aggregate is faulty. If both pats are good and the concrete laid in practice is faulty, the indication is that in the latter case, workmanship or weather is responsible.

It must be remembered that at the best these tests are " rough and ready " ; if they give satisfactory results there is evidence that the cement sets properly and is sound, but if the results are unsatisfactory, it is not at all certain that the cement is inferior in quality, because even with such apparently simple tests as these it is easy for a novice to make mistakes which vitiate the results.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Engineering and Building Foundations. Vol. I. Ordinary Foundations. By Charles Evan Fowler, C.E., Consulting Civil Engineer.

Chapman & Hall. Price 27s. 6d. net.

This is quite one of the best books on the subject we have seen. Its contents include a very interesting historical development, after which the actual construction and practice of crib coffer dams, cribs and canvas, pile driving and sheet piles, sheeting piles, construction of sheeting piles, removing old piers, pumping and dredging, is followed by the construction of ordinary foundations for all kinds of structures and on all kinds of conditions of the soil. Allocation and design of piers, calculation of piers, footings, and retaining walls, timber piers, and timber preservation, retaining walls and culverts, design of masonry abutments and masonry piers. The work is brimful of information—both on the theoretical and practical side, and is full of illustrations and examples taken from the best practice. The eleven appendices give the specifications, or extracts from specifications of many interesting bridges, dams, coffer dams, metal sheet piling, floating pile driver, United States cement specification—Navy Dept.—etc. Some idea of the information contained in this volume may be gathered from the fact of there being 286 excellent illustrations and 49 tables. The work is also excellently laid out and indexed. We know of no volume which collects so much valuable information on the subject which it deals with as this volume, and we confidently recommend it to anyone whose professional work requires ready reference to what has already been told on this very important subject. Mr. E. L. Corthell's excellent monograph on the allowable pressure on deep foundations, which is a work of the highest importance, finds a place in precis form—as indeed it should in any reputable work on this subject.

Concrete for House, Farm and Estate. (Second Edition.) By Fred Ballard.

Crosby, Lockwood & Son. Price 3s. 6d. net.

Nothing, perhaps, in the constructional methods of to-day is more striking than the large and ever-increasing variety of uses to which concrete is being applied in all directions, not merely as a substitute for other materials but as a structural material in itself. One of the reasons for this is to be found in the fuller appreciation of its valuable properties and its superiority for many purposes over timber, brick, iron and steel.

The numerous ways in which concrete can be employed on the estate and farm and for the erection of houses are described in a clear and interesting manner in a bright little book by Mr. Fred Ballard, obviously written by a practical man and addressed, not to the technologist, but to the ordinary reader.

We heartily endorse the opinions expressed in the preface that "An elementary knowledge of reinforced concrete should form part of the education of an Architect and Builder," and that "A careful study of the material will be rewarded by efficiency and reduction in cost." Mr. Ballard makes a good point when he says that for years to come the demand for timber will exceed the supply and the price will be high, and "If the demand for timber were confined to woodwork essentials, timber, and even bricks, might be largely excluded from general construction work in buildings by substituting reinforced concrete."

One of the advantages of concrete is that it is "composed of home material. Its all-round production and cost is mainly labour. With unskilled labour and a good foreman excellent results may be obtained."

The author is evidently a firm believer in sound workmanship and wisely emphasises the importance of efficient mixing, since, as he states, badly mixed concrete will spoil well-designed work, and a badly mixed 1 to 4 may not be equal to a well-mixed 1 to 8.

One fact, we think, is hardly brought out with sufficient clearness, and that is that 1 part of cement mixed with 2 parts sand and 4 parts coarse material, all by volume, does not produce a mixture of 1 part cement to 6 parts aggregate, since the greater part of the sand goes to fill the voids in the coarser aggregate. This is a point often lost sight of when proportioning.

The value of concrete for the elimination of the rat nuisance is strikingly illustrated, and the description of a rat-proof granary which has been in use for some years is very instructive.

The question of ensilage has never received in this country the consideration which it deserves; in America over half a million silos are in use. There is plenty of evidence, however, that British agriculturists are realising the value of this form of fodder and silos are now being erected all over the kingdom. It is interesting to learn that the first silo erected in Herefordshire was built in concrete on Mr. Ballard's farm, and his book very fittingly concludes with instructions for the erection of silos in concrete, than which in his opinion there is no more suitable material.

The book is written in very simple language, entirely free from technicalities, and should appeal to a very wide circle of readers.

QUESTIONS AND ANSWERS RELATING TO CONCRETE.

In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.

Question.—J. B. S. writes:—Having studied the valuable and simple article in CONCRETE *by Dr. Oscar Faber, will you be good enough to furnish me in a subsequent issue with a simple formula for Columns of ferro-concrete with eccentric load (say, for a travelling crane). Would you please also tell me if cantilevers are treated in exactly the same way as for beams, the only difference being the B.M.* $= \frac{WL}{2}$ *instead of* $\frac{WL}{8}$ *i.e.* $B.M. = M.R.\ 95 \times b \times d \times d$ *and the area of steel in the tension side* $A = \frac{\cdot 675}{100} \times d \times b$. *Is it safe to calculate a retaining wall as if it were a cantilever, provided the thrust is calculated for such a wall and used* *as the distributed load? According to the two formulas (cantilevers and retaining walls by Mr. Faber) the results are exactly similar.*

Answer.—Columns with eccentric loads must be calculated for concentric loads and for the bending moment. When the bending moment is small this may be done in exactly the same way as the treatment in "Reinforced Concrete Simply Explained" of last month's issue, where both the load and the bending moment on a certain column was given and the stress due to each calculated and added together. This formula is only strictly accurate in such cases where the eccentricity is so small that the stress due to bending is not greater than the stress due to the direct load. When the bending moment or eccentricity is appreciably greater, the method of calculation used in last month's article fails to be accurate because the moment of inertia of the column then becomes different owing to the concrete failing on the tension side. In this case there is no simple formula for calculation, and the easiest and most exact method is that given in *Reinforced Concrete Design*, Vol. I.

Cantilevers are treated in exactly the same way as for beams, bending moment being $\frac{W L}{2}$ for a distributed load, or $W L$ if the whole load is concentrated at the end, but the tension steel in the case of a cantilever with a downward load should be placed at the top instead of at the bottom and may be $\frac{\cdot 675}{100}\, b\, d$ when the resistance moment is taken as $R = 95\, b\, d^2$.

In reply to the last paragraph, a retaining wall is certainly a cantilever, provided the thrust and its point of application are correctly calculated. There are, however, several points about the design of the retaining wall which a knowledge of cantilevers does not suffice in solving—such as the distribution of pressure on the ground, the question of stability, and so on. Some of these questions are dealt with in *Reinforced Concrete Design*, Vol. I.

MEMORANDA.

Repairing Leaks in Concrete Water Tanks with Bran.—Two sub-surface concrete tanks which had been leaking badly were effectively sealed by the use of bran. The tanks in question measured 20 ft. in length by 10 ft. wide and 18 ft. in depth. The walls and floors were of reinforced concrete and were 10 in. thick at the top. Plastering of the inside faces of the tanks, which are built into the ground, proved to be of no use, as the water leaking from the outside washed the cement away as soon as it was applied; therefore some other way of making the tanks watertight had to be devised.

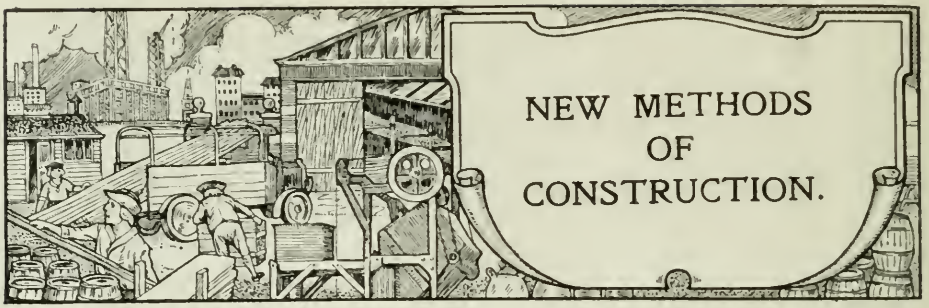
The following process was then tried with remarkable success. The tanks were filled with water, and the pressure being greater on the inside faces than the outside, the water ran out through the leaks to quite an extent. Ordinary bran was used as a sealing material. The surface of the water all around the walls for a width of about one foot, was covered with bran. This bran floats for some time until it takes a gluish form, when it starts to sink, but very slowly, and in going down, following the sides of the walls, the sticky substance is naturally drawn towards the holes into which it deposits itself, being forced in by the pressure of the head of water in the tank.

The operation was repeated until the tanks were made absolutely watertight. They have now been in use since November, 1919, and have not leaked at all since.—*Canadian Engineer.*

Repairing Stone Arch Aqueduct with Cement Gun.—The Pennsylvania State Highway Department recently made interesting use of the cement gun in repairing a stone arch aqueduct.

The stone arch was in very poor condition when the State took it over. The mortar joints had deteriorated so badly that some of the ring stones of the arches had fallen out.

In repairing this aqueduct to meet the requirements of a modern highway bridge, the joints in the cut stone face were raked and repointed by hand. The joints in the soffits of the arch rings were cleaned out and then shot full of mortar with a cement gun.



NEW METHODS OF CONSTRUCTION.

***In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.*—Ed.**

A SIMPLIFIED CONCRETE CAVITY WALL.

A new and simplified method of erecting concrete cavity walls has been devised by Messrs. Evans and Howarth.

The main features, as detailed in the accompanying drawing, consist of a timber core piece (which forms the cavity) on the outside of which is placed sheet iron to prevent adhesion of the concrete mixture to the core piece. A ring bolt is placed in the centre of the timber and is fitted with a loose link through which an iron lever bar can be inserted to form leverage and facilitate removal of the core piece after the concrete has set. On either side of the ring bolt, hand grips are fitted, allowing the centre to be easily lifted out by hand, once the lever has released the pressure.

The timber core piece is built of ordinary ⅝-in. spruce boarding with battens in the centre of the graduated thickness, in order to give the whole a taper of ¼-in. between the top and bottom, and both ends are boarded flush with the side. The covering consists of four pieces of light sheet iron, bent over at the ends and overlapping each other so as to prevent the cement from reaching the core piece. These pieces of sheet iron are held in position by wire bands.

The cores are placed in position between the wood shuttering, and the concrete is poured around and allowed to set, after which the cores are released, and are then available for use in raising to a second position.

Two small grooves are made in the base about 1¼ in. to allow the core piece to fit over the cavity ties placed in position on the set concrete, thus permitting the core piece to pass below the set concrete about 1 in., making the whole self-fixing and preventing any concrete from falling down the cavity.

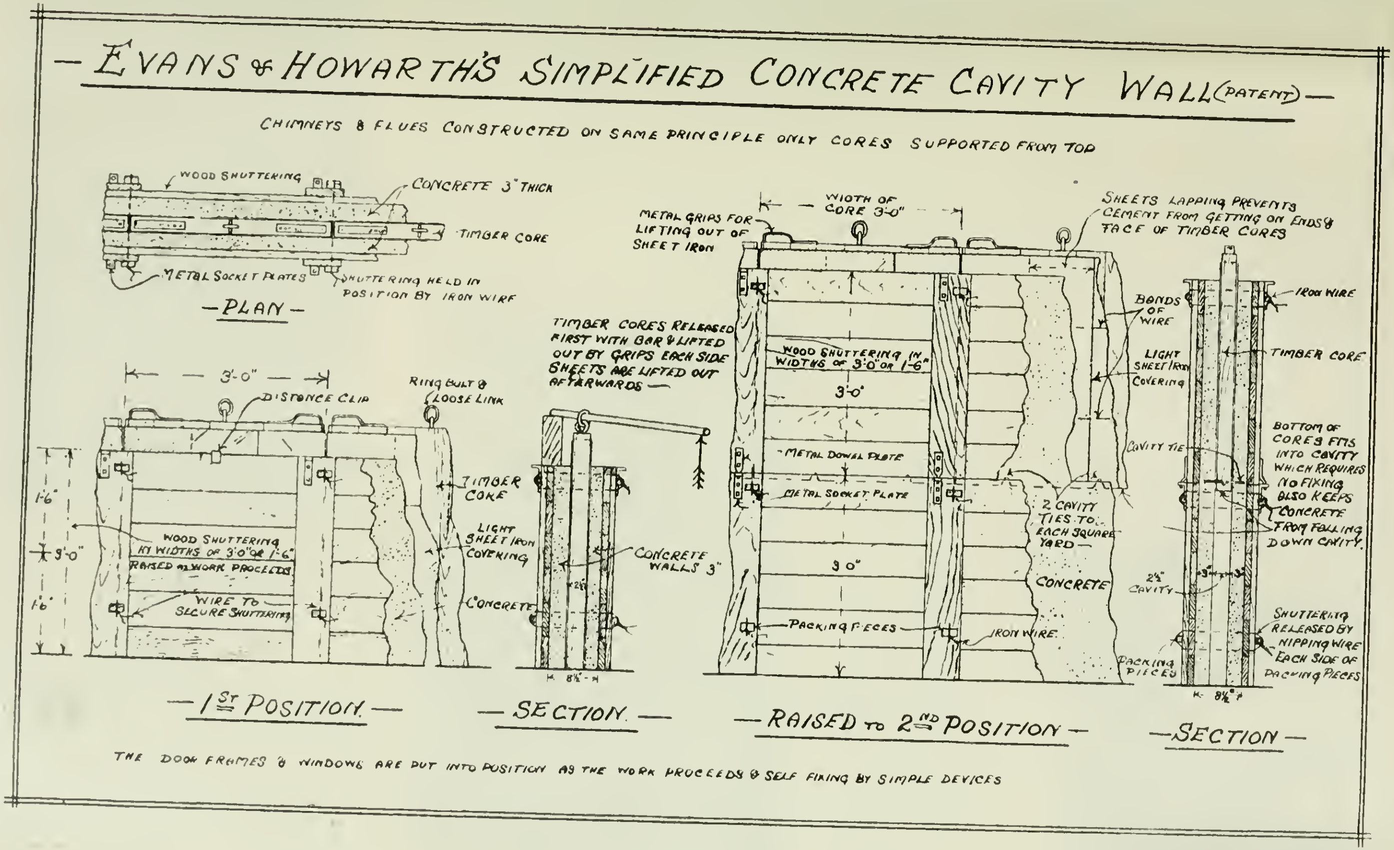
The cavity ties act as a support for the core piece and prevent the iron sheets from falling down the cavity when the timber cores have been removed.

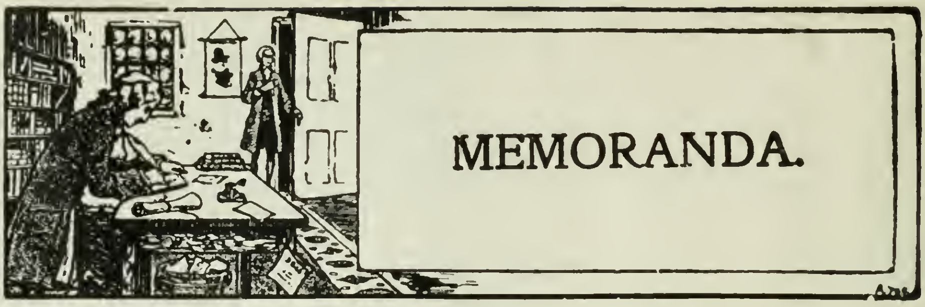
This method can be adapted to the construction of chimney stacks and flues.

The advantages claimed for this method of construction are :

1. The whole of the work can be carried out by unskilled labour.
2. The cost of plastering is considerably reduced as the walls will not require "rendering" with hair mortar, as skimming over only will be necessary.
3. Window frames and doors are placed in position as the work proceeds, and secured by simple devices which entirely do away with the usual method of securing same by nailing.
4. A saving of time is effected.

Further information can be obtained from Messrs. Evans & Howarth, Contractors, Whitefield Road, Liverpool.


— EVANS & HOWARTH'S SIMPLIFIED CONCRETE CAVITY WALL (PATENT) —
CHIMNEYS & FLUES CONSTRUCTED ON SAME PRINCIPLE ONLY CORES SUPPORTED FROM TOP
WOOD SHUTTERING
CONCRETE 3" THICK
TIMBER CORE
METAL SOCKET PLATES
SHUTTERING HELD IN POSITION BY IRON WIRE
— PLAN —
3'-0"
DISTANCE CLIP
RING BOLT & LOOSE LINK
TIMBER CORE
LIGHT SHEET IRON COVERING
CONCRETE
WOOD SHUTTERING IN WIDTHS OF 3'0" OR 1'-6" RAISED AS WORK PROCEEDS
WIRE TO SECURE SHUTTERING
1'-6"
3'-0"
1'-6"
— 1ST POSITION —
TIMBER CORES RELEASED FIRST WITH BAR & LIFTED OUT BY GRIPS EACH SIDE SHEETS ARE LIFTED OUT AFTERWARDS —
CONCRETE WALLS 3"
2½"
8½"
— SECTION —
METAL GRIPS FOR LIFTING OUT OF SHEET IRON
WIDTH OF CORE 3'-0"
SHEETS LAPPING PREVENTS CEMENT FROM GETTING ON ENDS & FACE OF TIMBER CORES
WOOD SHUTTERING IN WIDTHS OF 3'-0" OR 1'-6"
3'-0"
METAL DOWEL PLATE
METAL SOCKET PLATE
3'0"
PACKING PIECES
IRON WIRE
BONDS OF WIRE
LIGHT SHEET IRON COVERING
CAVITY TIE
2 CAVITY TIES TO EACH SQUARE YARD
CONCRETE
— RAISED TO 2ND POSITION —
IRON WIRE
TIMBER CORE
BOTTOM OF CORES FITS INTO CAVITY WHICH REQUIRES NO FIXING ALSO KEEPS CONCRETE FROM FALLING DOWN CAVITY.
2½" CAVITY
3"
3"
SHUTTERING RELEASED BY NIPPING WIRE EACH SIDE OF PACKING PIECES
PACKING PIECES
8½"
— SECTION —
THE DOOR FRAMES & WINDOWS ARE PUT INTO POSITION AS THE WORK PROCEEDS & SELF FIXING BY SIMPLE DEVICES



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—Ed.

Curiosities near Salisbury.—The accompanying illustrations show interesting and unusual uses of concrete, both of which are to be found at Lake, near Salisbury. *Fig.* 1 is a single storey dwelling that was built about fifty years ago, to house a loom at the time when an effort was being made to revive village handicrafts. On a plinth of brickwork a timber framing was fixed and to this framing boards were nailed which formed a shuttering, the boards were subsequently removed but the timber frame remained. The wall is thus solid concrete panels enclosed by timber uprights cill and plate. The fall of the ground enabled cellars to be constructed. The attempt at reviving the hand-loom not proving a success, the building was used as a dwelling, which purpose it still fulfils with entire satisfaction.

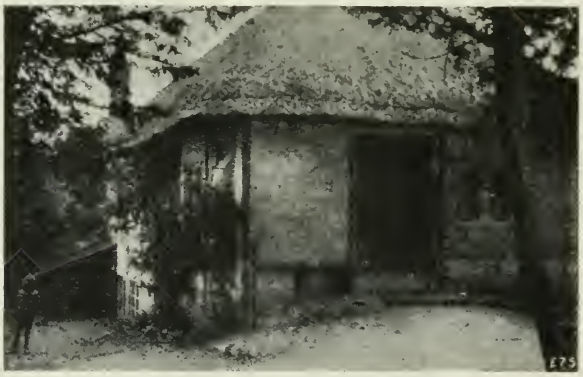


Fig. 1. Curiosities near Salisbury.

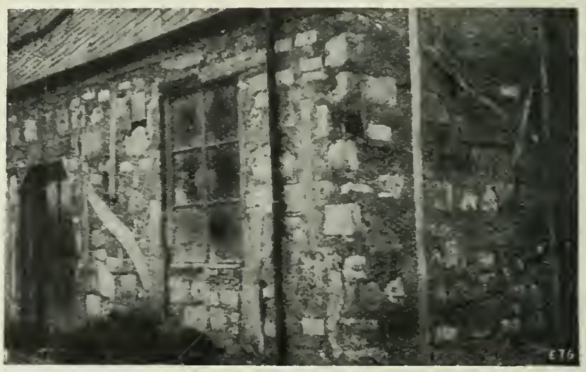
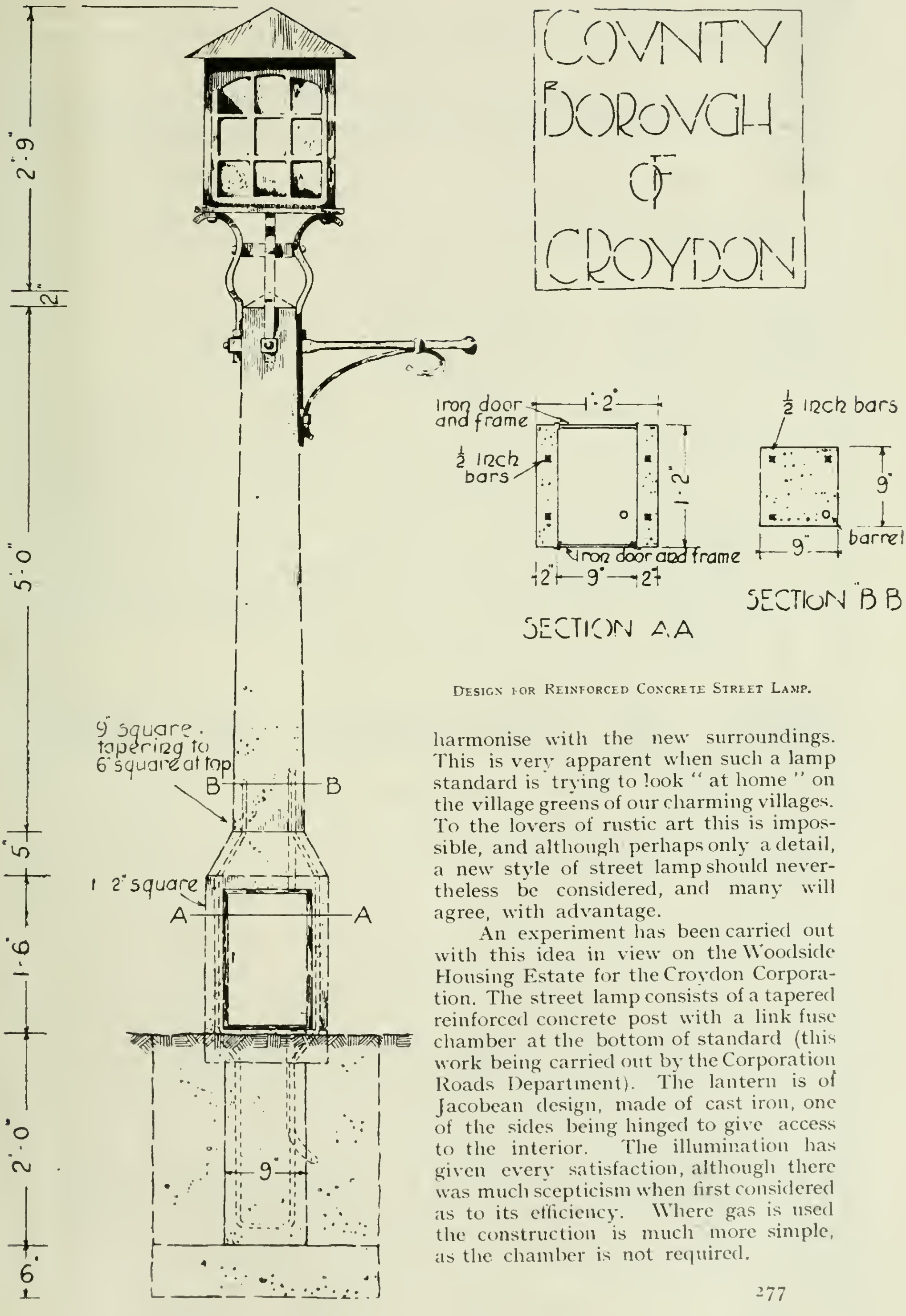


Fig. 2. Curiosities near Salisbury.

Fig. 2 shows the corner of a small power-house on a private estate. The walls were built up between shuttering and every kind of rubbish was used in the process, including stone, broken brick and tiles, tin and timber. Although several repairs have been effected to the building since its erection it still seems to perform its function adequately.

Reinforced Concrete Lamp Posts.—The advent of town planning and the endeavour to lay out new estates and suburbs on garden city principles suggests very strongly that the somewhat prehistoric iron street lamp standards so dear to gas and electrical engineers do not



Design for Reinforced Concrete Street Lamp.

harmonise with the new surroundings. This is very apparent when such a lamp standard is trying to look "at home" on the village greens of our charming villages. To the lovers of rustic art this is impossible, and although perhaps only a detail, a new style of street lamp should nevertheless be considered, and many will agree, with advantage.

An experiment has been carried out with this idea in view on the Woodside Housing Estate for the Croydon Corporation. The street lamp consists of a tapered reinforced concrete post with a link fuse chamber at the bottom of standard (this work being carried out by the Corporation Roads Department). The lantern is of Jacobean design, made of cast iron, one of the sides being hinged to give access to the interior. The illumination has given every satisfaction, although there was much scepticism when first considered as to its efficiency. Where gas is used the construction is much more simple, as the chamber is not required.

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CONCRETE AND HOUSING SCHEMES.

Chester.—The Chester Town Council has instructed the Borough Surveyor to obtain information regarding systems of concrete construction in connection with the erection of 140 houses on the Heath Lane side.

Chirbury.—The Chirbury Rural District Council is considering the erection of concrete houses in connection with its housing scheme.

Edinburgh.—The Edinburgh Dean of Guild Court has granted an application of the Edinburgh Corporation for the erection of 306 concrete houses under the Wardle housing scheme.

Grays.—The Housing Commissioner for the area has approved the erection by the Grays Urban District Council of a further 100 concrete houses on the "Duo Slab" system.

Ipswich.—The Ipswich Corporation has decided to erect twenty-two five-room bungalows with concrete walls, at a cost of £780 each, and also to build 364 other houses.

Stow-on-the-Wold.—The Ministry of Health has urged the Stow-on-the-Wold Urban District Council to carry out its housing schemes in concrete, on the grounds of economy.

Swansea.—The Housing Committee of the Swansea Corporation has recommended that a contract be entered into with Messrs. W. Nicholls, Ltd., for the erection of sixty steel-frame concrete houses on the Llanerch site.

Thorne.—The Thorne Rural District Council has decided to proceed as soon as possible with the erection of 166 "Dorlonco" steel and concrete houses and 133 brick houses at Stainland, the whole to be completed by July 1, 1922. The Public Works Loan Board has sanctioned a loan of £156,000 for the purpose.

Tilbury.—The Tilbury Urban District Council has decided to invite applications for the erection of 250 houses, on the "Winget" concrete block system.

NEW METHODS AND MATERIALS.

The following are some further materials and new methods of construction approved by the Standardisation and Construction Committee:—

J. Weston, 203, Hamlet Gardens, Ravenscourt Park, London, W.6.—"Westlin" System.—This system produces a block built cavity wall, the external blocks being of ballast concrete and the inner of clinker. Each block is made with lugs of such a form that the outside and inside blocks lock together.

Messrs. Young & Co., 6, Queen Anne's Gate, Westminster, S.W.1.—The "Fewac" System of Construction.—This system consists of a steel frame structure, the uprights in the wall being cased with ballast concrete, and the panels between being filled in with 2½ in. clinker slabs finished internally with plaster. Vertical battens are fixed on the outsides of the slabs and the exterior face is finished with weather boarding. The system is eligible for a loan period of 40 years and for two-thirds of the amount of the Grant to private builders.

PROSPECTIVE NEW CONCRETE WORK.

AMWELL.—*Bridge.*—The Herts County Council proposes to erect a heavy weight-carrying bridge at Lowbridge, Amwell.

ATHERSTONE.—*Water Supply.*—The Atherstone Rural District Council has decided to apply for the sanction of the Ministry of Health for a loan of £64,000 for a water-supply scheme.

BRISTOL.—*Waterworks.*—The Bristol Water Company has submitted to Parliament a Bill for power to construct a new waterworks.

BRIXHAM.—*Reservoir.*—The Ministry of Health has held an inquiry into the application of the Brixham Urban District Council for sanction to borrow £3,000 for the construction of a reservoir.

CHICHESTER.—*Waterworks.*—The Chichester Town Council is considering an application to the Ministry of Health for sanction to a loan of £13,000 for extensions at the waterworks.

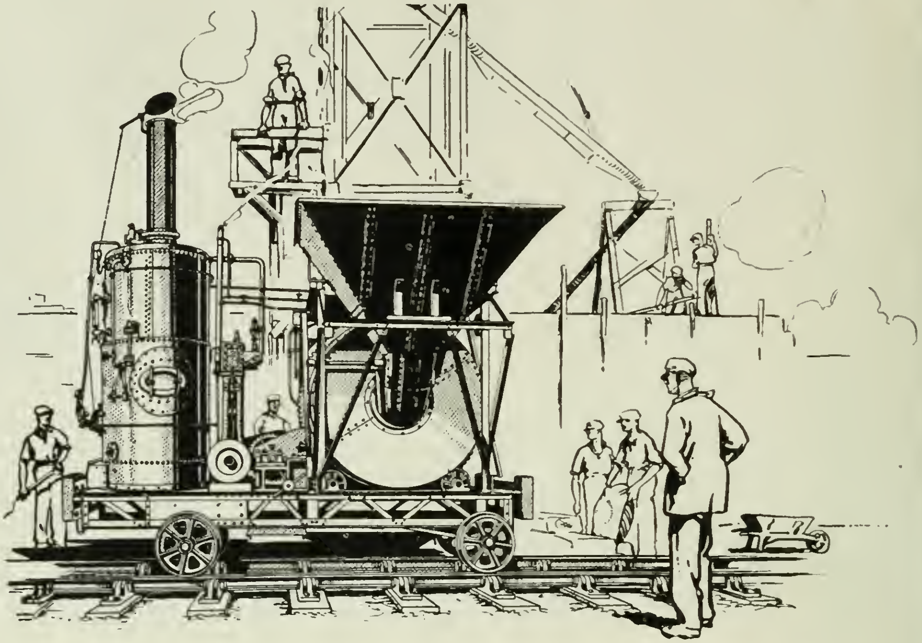
DAMFLASK.—*Floor.*—The Sheffield Corporation proposes to erect a timber house on a concrete floor, at the cost of £5,250, at the Damflask Reservoir.

DENBIGH.—*Bridge.*—The Denbigh County Council has received sanction to the borrowing of £4,500 for the reconstruction of Alyn Bridge.

DENNISTOUN.—*Road.*—The Lanark Lower Ward District Committee is considering the construction of a new road between Bargeddie and Dennistoun, at an approximate cost of £120,000.

DUMBARTON.—*Waterworks.*—The Dumbarton Town Council has decided to apply for sanction to a loan of £50,000 for waterworks extensions.

DURHAM.—*Road.*—The Durham County Council has decided to construct a new road connecting Hartlepool, Blackhall, Horden, and Easington, at an estimated cost of £270,000.



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Holyhead.—*Harbour Works.*—The London & North-Western Railway Co. is negotiating with the Government for a new lease of Holyhead Harbour, and proposes to carry out extensive developments.

Hornsea.—*Sea Wall.*—The Hornsea Urban District Council is considering the construction of sea-defence works, at an estimated cost of £10,000.

Keighley.—*Waterworks.*—The Keighley Corporation has received sanction to a loan of £200,000 for the extension of the waterworks at Sladen Valley.

Llanelly.—*Wharf.*—The Reliance Fuel Co. of Llanelly has decided to construct a new wharf at Llanelly, at a cost of about £400,000.

Portland.—*Sea Wall.*—The Portland Urban District Council Engineer is preparing plans for the construction of a sea wall, estimated to cost £4,000.

Wenlock.—*Waterworks.*—The Wenlock Waterworks has approved of a scheme for the extension of the waterworks at Harrington, at a cost of £10,000.

Weymouth.—*Embankment.*—The Dorset County Council has decided to construct an embankment and a dam over the Backwater, at a total cost of £26,305, and has received a grant from the Ministry of Transport towards the cost.

Yarmouth.—*Sea Wall.*—The Yarmouth Town Council has agreed to construct a sea wall from the Revolving Tower to Sandown road, at a cost of £6,000.

Yeovil.—*Reservoir.*—The Yeovil Town Council has decided to proceed as soon as possible with the construction of a reservoir of 750,000 gallons capacity at Hendford Hill.

TENDERS ACCEPTED.

Brentford.—The Brentford Urban District Council has recommended to the Housing Board for acceptance the tender of the Improved Concrete Construction Co. of London, for the erection of 20 concrete houses, at a total cost of £16,413.

Bromborough.—The Bromborough Urban District Council has accepted the tender of Messrs. Oliver & Co. for the erection of 16 Type " B " houses on the " Cyclops " system of concrete block construction, at £965 per house.

Croydon.—The Croydon Town Council has accepted the tender of the Hydraulic Mining Cartridge Co., for the removal of a concrete foundation bed at the electricity works, at 40*s.* per cubic yard.

Kirkcaldy.—The Kirkcaldy Town Council has accepted the tender of Messrs. Casey & Darragh of Stirling, for the construction of a concrete tank at Navitie, and other work, at £23,788 17*s.* 7*d.*

Lancashire.—The Lancashire County Council has accepted the tender of Messrs. Parkinson & Son for the erection of ten pairs of concrete cottages on the Howick, Hutton and Longton Estates, at £318 per pair.

Macduff.—The Macduff Town Council has accepted the tender of Messrs. G. Duncan & Sons, of Inverurie, for the supply and fixing of the cast concrete work in connection with its housing scheme, at £10,494 10*s.* 4*d.*

Middleton.—The Middleton Town Council has submitted to the Housing Commissioner the following tenders for the erection of 64 houses on the Boarshaw (North) site :—In concrete : Messrs. J. H. Bardsley, Manchester : £3,552 per block of four ; in brick :—Messrs. J. Metcalf, Manchester : £4,180 per block of four.

Northampton.—The Northampton Corporation has accepted the tender of Mr. W. Higgins, of Northampton, for the erection of 118 concrete houses, at £1,670 per pair.

Plymouth.—The Housing Commissioner for the area has approved of the acceptance by the Plymouth Town Council of the tender of Messrs. E. E. Endicott for the erection of 26 Type " A " houses at £885 per house and 26 Type " B " houses at £974 per house, on the " Dorlonco " system of steel and concrete construction.

South Shields.—The South Shields Town Council has accepted the following tender for the construction of 72 in., 60 in. and 48 in. diameter brick and concrete culverts at the Brinkburn and West Horton Outfall Sewers :—Brinkburn : G. Bailey & Co., Ltd., Newcastle-on-Tyne, £21,446 8*s.* 6*d.* ; West Horton : G. Bailey & Co., Ltd., Newcastle-on-Tyne, £6,692 12*s.* 2*d.*

TENDERS INVITED.

Durham.—April 13. For construction of two tunnels under Stanhope and Muggleswick Commons, of a total length of about three miles, together with shaft boring and other work, for the Durham County Water Board. Specifications, etc., from Messrs. T. and C. Hawksley, Engineers, 62, Broadway, Westminster, S.W.1. Deposit, £3 3*s.*

Manchester.—April 28. The Manchester Ship Canal Co. invite tenders for the construction of a reinforced concrete quay, and the foundations for transit sheds, at Trafford Wharf, Manchester Docks. Specifications, etc., from Mr. H. A. Reed, Chief Engineer, 41, Spring Gardens, Manchester. Deposit, £2 2*s.*

Monte Video.—April 18. Construction of bridge over the Santa Lucie River, for the Ministry of Public Works. Further particulars from Inquiry Office, Dept. of Overseas Trade, 35, Old Queen Street, S.W.

BUILDING TRADES EXHIBITION.

Among the firms represented at the Building Trades Exhibition is the **Concrete Utilities Bureau,** of 35, Great St. Helens, London, E.C.3, at whose Stand, No. 108, Row F, free literature on the manifold uses of concrete may be obtained, and the following volumes will be on sale:—*Concrete Cottages, Small Garages, and Farm Buildings,* by Albert Lakeman, M.S.A., and *Concrete Roads,* a recently published work containing valuable data on concrete roads in the United Kingdom and other countries, collected by the Editor of *Concrete and Constructional Engineering.*

A New Block Machine.—A cheap and handy machine for making blocks, slabs and bricks is being exhibited by **Messrs. Winget, Ltd.,** at their Stand, No. 123, Row G. This machine, known as the "Westminster," is particularly suited to the small builder and estate owner. More particulars with illustration will appear in our next issue.

CHANGE OF ADDRESS.

The Indented Bar and Concrete Engineering Co., Ltd., have secured a more commodious suite of offices on the first floor of the same building in which their offices at present are, namely, Queen Anne's Chambers, Westminster, S.W.1.

Christiani & Nielsen.—We are asked to state that Messrs. Christiani & Nielsen have removed from their present offices at 25 and 124, Victoria Street, to more commodious offices at 72–74, Victoria Street, S.W.1.

NEW COMPANIES REGISTERED.

Manelite Patent Concrete Machinery Co., Ltd. (173,235). Registered February 18. To acquire Letters Patent No. 119,206 of 1918 for an invention of "Improvements in Machinery employed in the manufacture of Concrete and the like wall blocks." Nominal capital, £10,000, in 10,000 £1 shares. Directors: F. T. Cutley, 61, Lowther Road, Bournemouth; H. E. Hawker, St. Peter's Chambers, Bournemouth; J. H. Jones, 22, Poole Road, Dorset; G. T. McWilliam, Canford Cliff Road, Canford Cliffs, Dorset; C. D. Newton, 135, Lowther Road, Bournemouth; and P. H. Parsons, 8, Durrant Road, Bournemouth. Qualification of Directors, 100 shares; remuneration to be voted by Company.

Metallic Plastering and Renovations, Ltd. (173,236). 43, London Wall, E.C. Registered February 18. Workers in metal, cement and other plasters. Nominal capital, £1,000, in 1,000 £1 shares. Directors: H. C. Gardner, 29, Grosvenor Road, Richmond; A. E. Saw, "Ravells," Oakleigh Park Drive, Leigh-on-Sea; and E. Mulroy. Qualification of Directors, one share; remuneration to be voted by Company.

Ferrate Manufacturing Co., Ltd. (173,435). Registered March 1. Builders, contractors, and manufacturers of concrete, Green Street Green, Farnborough, Kent. Nominal capital, £10,000, in 10,000 £1 shares. Directors: S. E. Thomas, Temple Farm, Brinkley; E. G. Livermore, Bank House, Orpington, Kent; J. E. Bennett, Cotfield, Kemsing, Kent; W. G. Paine, 381, Croydon Road, Caterham, Surrey; H. E. Routledge, 13, Tregothenan Road, Stockwell, London, S.W.; H. B. Byles, Hardwick, Long Stretton, Norfolk; G. F. Spreckley, 513, Barking Road, E.13. Qualification of Directors, £5; remuneration to be voted.

Excelsior Patent Stone Co., Ltd. (173,476). Registered March 3. Finedon Buildings, Finedon, Wellingborough. Artificial stone manufacturers and dealers. Nominal capital, £10,000, in 5,000 £1 preference shares and 5,000 £1 ordinary shares. Directors: D. K. Kingston, Finedon. Qualification of Directors, £100; remuneration to be voted.

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PRESS APPROVAL.

The Builder.—"This book is published at an opportune time. . . . It is a handy and well-arranged volume, which may be recommended to all interested in the subject dealt with."

Municipal Journal.—"This admirable book can be safely recommended to municipal engineers and their assistants."

Surveyor.—"Road engineers will warmly welcome the book on Concrete Roads. It is very well illustrated with photographs of the roads. The book will be found extremely useful by all road engineers, and make a valuable addition to their libraries."

Financial News.—"This question is discussed fairly and without prejudice in Concrete Roads. . . . The book forms a valuable addition to literature on the subject."

Motor Transport.—"A well-illustrated book . . . which deals with this important subject in a very lucid and interesting manner."

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 5. LONDON, MAY, 1921.

EDITORIAL NOTES.

BUILDING TRADES EXHIBITION.

It is certainly unfortunate that the Building Trades Exhibition should have coincided with the gravest industrial crisis that the country has witnessed since the war. The trade depression of the previous months had unavoidably made itself felt in the building industry, and a period of hesitancy had set in. It was hoped, however, that the Exhibition would act in some degree as a stimulus both to the layman and to the builder. The former would see that the prices of certain materials and commodities were undoubtedly lower than those quoted at the last exhibition, and he might thus be inclined at last to put in hand work which had hitherto suffered continual postponement owing to high cost. And the latter might feel disposed to purchase certain items of new equipment and plant, the acquisition of which had been delayed until a comprehensive comparison, such as is only possible at these gatherings, could be made. Although the attendance at the exhibition was good the enthusiasm of last year was lacking, for the minds of many visitors were occupied with other things. Even municipal housing undertakings have become infected with this spirit of irresolution, and in many instances large schemes are held in abeyance.

CONCRETE CONSTRUCTION.

During the year many of the patent systems of construction have undergone practical tests; some have failed and dropped into oblivion, others have survived, and certain new ones make an appearance this year for the first time. As heretofore concrete appeared in a multitude of guises showing its versatility and its suitability for numerous purposes. Although it was the exhibition of 1920—the first post-war gathering—that showed the most marked increase in concrete development, nevertheless this year's exhibits testified to the increasing use of this material, and it must have been apparent to the most casual observer that the new uses to which concrete was put during the war were no mere emergency measures, but were legitimate uses of one of the finest, and, let it be remembered, one of the oldest of building materials. Last year, to many, the sight of so large a number of block-making machines at work constituted a diversion; this year, however, their interest was of a more practical nature, comprising enquiries as to comparative costs, daily output, shape of the block produced, method of tamping, and the like.

THE SURFACE TREATMENT OF CONCRETE.

Nevertheless in one direction, at least, we would have wished to see concrete far more prominent. A casual visitor to the exhibition would have left convinced that, whatever can be done with concrete, there is one purpose for which it is no use, and that is to produce a fine richly textured surface ; it cannot, in fact, compete with the best quality brickwork or masonry. It may be suitable, the casual visitor would argue, for structural work of all kinds, and for smaller domestic work, but in monumental architecture, where beauty and colour of texture are important considerations, if it be used its face must be hidden. This is fortunately an utter fallacy, but evidence to prove it is sadly lacking in this country. We have drawn attention to this matter on previous occasions and we shall continue to do so in the future. Just as the manufacturers of bricks display their choicest effects of walling, so too concrete machine manufacturers should have displayed portions of walling built with various rich aggregates and treated in various ways. Here is a vast area for conquest.

MUNICIPAL AND OTHER EXHIBITS.

The growing importance of the municipality as a constructive agent, both in matters of engineering and of building, was also manifest, and the segregating of exhibits of particular interest to such bodies to the gallery was an excellent innovation. The exhibition, indeed, was primarily one of practical things, the aspects of building as a fine art were not prominent. There were, of course, exhibits of rare and beautiful timbers, of exquisitely marked marble, and of fine paintwork, but the sense of these things was overborne by a more profuse abundance of hot water apparatus, kitchen equipment, concrete mixing machinery and chestnut paling. Another comparison between the recent exhibition and that of 1920 might be made by stating that the tone of the former was saner than that of its predecessor. The period succeeding the war and preceding the 1920 exhibition witnessed a veritable outbreak of inventive ingenuity. Much of it, however, defeated the very object for which it should have been devised by substituting one kind of complication for another ; it was a period of " gadgets," each inventor seeking to outdo his neighbour, forgetting that each addition added to the cost and likewise to the number of moving parts, so increasing the risk of a breakdown. Thus the visitor, fascinated as he was by a demonstration of an automatic " washer up," or by a vision of a super-dresser with a place for everything, was deterred from buying them, partly on account of their cost and partly on account of conservatism ; that deplorable, but nevertheless almost universal, human characteristic. Only the soundest of this class of commodity has survived the year's test, and emerged solvent.

It is in observing, or perhaps in merely feeling, such differences as those indicated that the pulse of the age—the pulse of the fleeting moment—can be apprised, and the almost insensible change, that seems ever without intermission to sway the course of our progress from following a direct line, be noted.

GENERAL ARRANGEMENT.

We notice that a contemporary draws attention to the lack of cohesion in the arrangement of the exhibits and in the design of the stalls. It is an opportunity for a comprehensive layout scheme, which requires architectural knowledge, and it is suggested that a committee of three be formed composed of an architect, a trader, and a member of the officiating committee whose function it would be to " approve or disapprove and advise upon the design of the stalls," and whose decision would be final. Much invective will doubtless be hurled at the head of the originator (in this instance Professor A. E. Richardson, F.R.I.B.A.) of this suggestion, for it will be felt that it savours of interference with the liberty of the subject ; of autocracy. For our own part we heartily concur with the suggestion, and agree, furthermore, with the writer of the article when he points out how superior is the arrangement of such a gathering when it is organised on the Continent or in America. A demand for beauty in mundane things is incipiently asserting itself, for in another contemporary we have been delighted to see a plea for better design and colouring in such objects of use as street lamps, pillar boxes (though the design and colour of the latter is at present excellent) and sand bins. Surely the Building Exhibition might be expected to give its support to such a laudable endeavour.

Thus in next year's exhibition we shall eagerly look for two improvements, one affecting the general arrangement of the hall, and the other affecting that particular class of exhibit in which we are naturally most interested.

A STEP FORWARD ON THE PART OF THE CONCRETE INSTITUTE.

A short time ago we recorded the fact that the Council of the Concrete Institute were considering the formation of a new class of membership. The *fons et origo* of this was that the Institute had, from time to time, received applications from foremen or from clerks of works and others who, while they could not be included in the category of professional men, nor of those who had had University training, yet had a thorough practical knowledge of concrete work. It was felt by the Council that the time had arrived when such persons should be admitted to the advantages of membership of the Institute, and it has been decided that a new class should be created and that its members should be known as Licentiates, the licence to be held under conditions laid down by the Council.

This we consider a very wise and commendable step on the part of the Council and one that should be of mutual advantage to both the Institute and the Licentiates themselves. On the one hand the scope of the Institute's activities and influence is widened and the organisation will always be able to obtain, at first hand, the opinion of the *practical* expert. On the other hand, the licentiateship of such a body as the Concrete Institute will give a certain status to the holder which will be a guarantee of his efficiency, and membership of this class will include many advantages and privileges which the Institute can confer.

We welcome this move, too, because it is in conformity with the spirit of the age, a spirit which is leading more and more towards a closer co-operation and a better understanding between the professional and the practical worker.

GENERAL NOTES.

DESIGNS FOR PROPOSED CONCRETE WORK.

It has been our practice hitherto, in these pages, to describe and illustrate work actually carried out, but we feel that it might be helpful and suggestive, as well as of general interest, to publish designs of proposed buildings, together with a brief description of same, where it is suggested that concrete or reinforced concrete should be the principal material used in the construction of such work. We, therefore, invite architects, engineers and others to send in such proposed designs, accompanied by brief descriptive notes.

A CONTRACTOR'S PAGE.

There are often points of difficulty that arise in the course of executing large building and engineering works; these have to be solved on the job by the superintending engineer or clerk of works. We believe it would be of general interest if such problems and their solution were briefly described from time to time, and we therefore invite engineers, contractors and others concerned to send us information of this kind for publication, together with diagrams or photographs, where such are needed for explanation.

At the present time when greater attention is being given to the general layout of the plant, notes on this question would also be useful.

THE USE OF CLINKER FOR BLOCKS AND SLABS.

In a recent issue of "Housing" the Ministry of Health emphasise the need of adhering to their specification when manufacturing blocks and slabs of clinker, for they state that unburnt coal is frequently found in their composition. The article goes on to say that :—

"It is necessary to direct attention to this matter, as serious results may ensue when such blocks and slabs are used. In a recent case certain slabs were tested and it was found that after immersion in water for one night, they had burst. In another, the blocks were finished fair face in fine ballast concrete, and after being built into the wall the face cracked and broke away while the slab itself was fractured. In each case coal was exposed on the line of fracture.

"It is desirable for all users of blocks or slabs, which are not under proper technical supervision in accordance with the specification but are bought from manufacturers, to insist on a guarantee from the manufacturers that they have been made in accordance with the Ministry's Specification for Cement Concrete Building. In some cases, the sand specified for the clinker aggregate is not required, and it is found that a stronger block or slab can be made when the sand is omitted than when it is added, but this depends entirely on the nature of the aggregate and can only be determined by experiment.

"Where the blocks or slabs are to be finished with plaster or rough cast it is necessary to see that they are cast with a face sufficiently rough for the purpose, to avoid unnecessary labour in scoring after they are built to provide a key."

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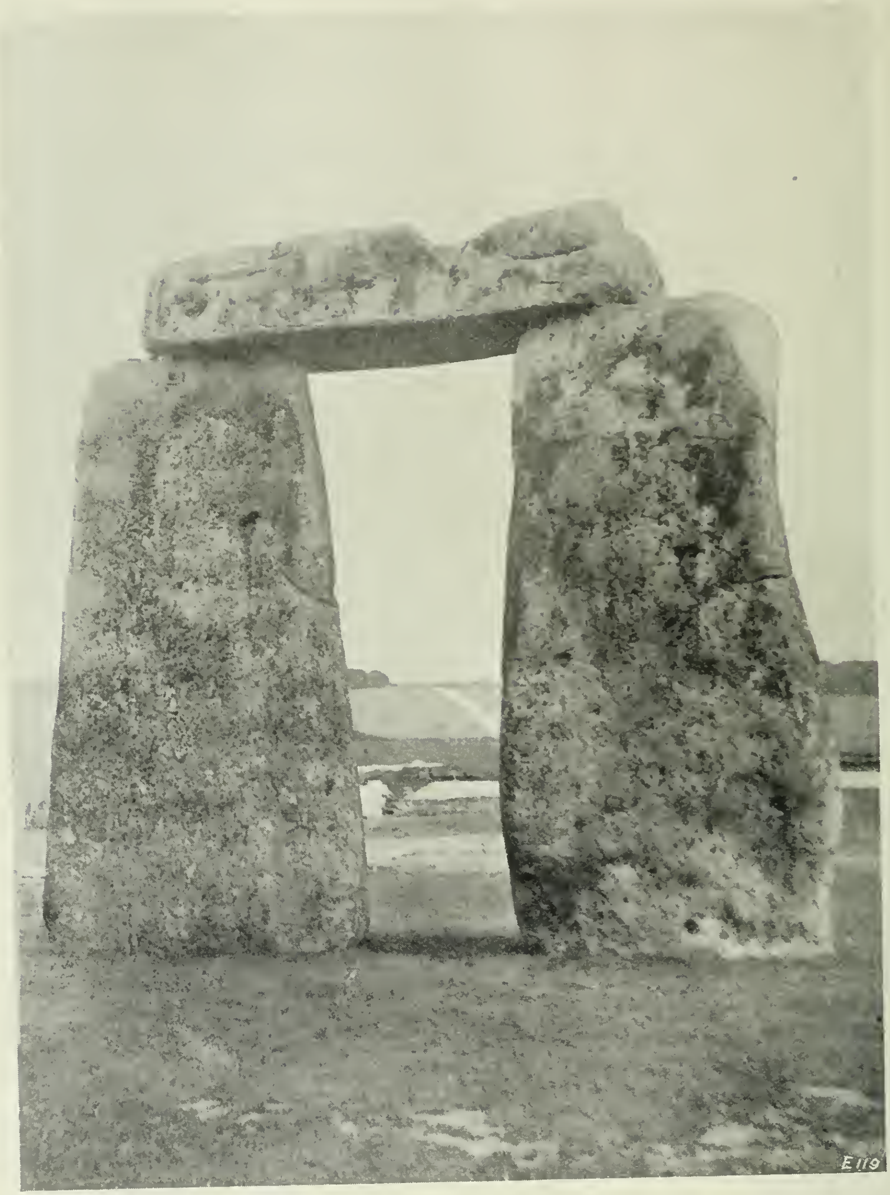
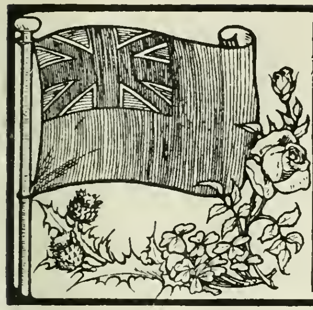


STONES NOS. 6 AND 7 AT STONEHENGE AFTER ADJUSTMENT.
(See article, p. 287.)



STONEHENGE.

AN ACCOUNT OF THE WORK CARRIED OUT BY H.M. OFFICE OF WORKS.

An interesting instance of the use of reinforced concrete in preserving our ancient monuments has recently occurred at Stonehenge, and by the courtesy of H.M. Office of Works, we are able to give the following particulars and accompanying illustrations of this work.—ED.

It will be remembered that Stonehenge was presented to the nation by Sir Cecil Chubb in 1918. At that time it was realised that the stability of many of the stones, still maintaining an upright position, was very uncertain, and His Majesty's Office of Works, in the spring of 1919, undertook a most thorough survey of the stones under the direction of Sir Frank Baines, C.B.E., M.V.O., in order to ascertain the conditions of stability and other details concerning each individual stone. Before embarking upon a detailed account of this work, a short description of the whole erection may be of interest.

Stonehenge is the name given to a number of large stones standing on Salisbury Plain, near Amesbury. Its exact date is unknown, but it has been computed by Sir Norman Lockyer to be as early as 1780 B.C. The stones are arranged in circular formations; the outer circle of Sarsen stones, which average 14 ft. high above the ground, has a diameter of 97 ft. 4 in. to the inner face. Of the thirty uprights and thirty lintels which originally comprised this outer circle, only sixteen uprights are now standing, and only five lintels are still in position. Within this outer circle is a ring of blue stones whose geological formation is not of local origin. These stones are smaller and without lintels; only nine of them are standing to-day. Within the circle of blue stones are five Trilithons, arranged in the form of a horse-shoe. Each is composed of two imposts and a lintel across the top. The largest of the imposts is the famous "leaning stone," which is said to be the largest native stone in England, being 22 ft. high above ground with 8 ft. below. In the seventeenth century some excavations were made to this stone which caused it to assume an even more dangerous position, until in 1901, when it was moved upright, it inclined at an angle of 25°. To-day six of the imposts are standing and two lintels are in place. Within the Trilithon horse-shoe there is yet another circle composed of about twelve small blue stones. Close to the centres of these circles lies the so-called "Altar Stone." Outside the circles lie the Hele Stone, the Slaughter Stone, the S.E. and the N.W. stones. It is calculated that originally there must have been a weight of about 1,500 tons of stone used in the construction of the circle. To-day only about half the stones are standing, but none has fallen for about twenty years.

The first operation in connection with the survey was to drive in six pegs round each upright stone; these were then connected to the main theodolite survey lines. By means of plumb lines offsets were taken at 12 in. vertical intervals, or at points where the contour of the stone changed. These surveys were then plotted out and four elevations and a plan at ground level were made of each stone. In the case of those stones which appeared to be dangerously out of the vertical, horizontal cross-sections were drawn at every foot in height. The centres of gravity of the stones were plotted on the elevations, from which a line of thrust was drawn. In the case of stones carrying lintels, the weight of these was combined with the line of thrust (tests with fragments of Sarsen stones showed a specific gravity of 2·4, which equals 150 lb. per cubic foot) and a wind pressure of 40 lb. per square foot was assumed. The modulus of the horizontal section at ground level was found graphically, and thus the stress on the stone due to bending and due to the direct load was obtained. The maximum stresses in the case of No. 7 stone were, for compression, 78 lb. per square inch, and for tension 37 lb. per square inch.

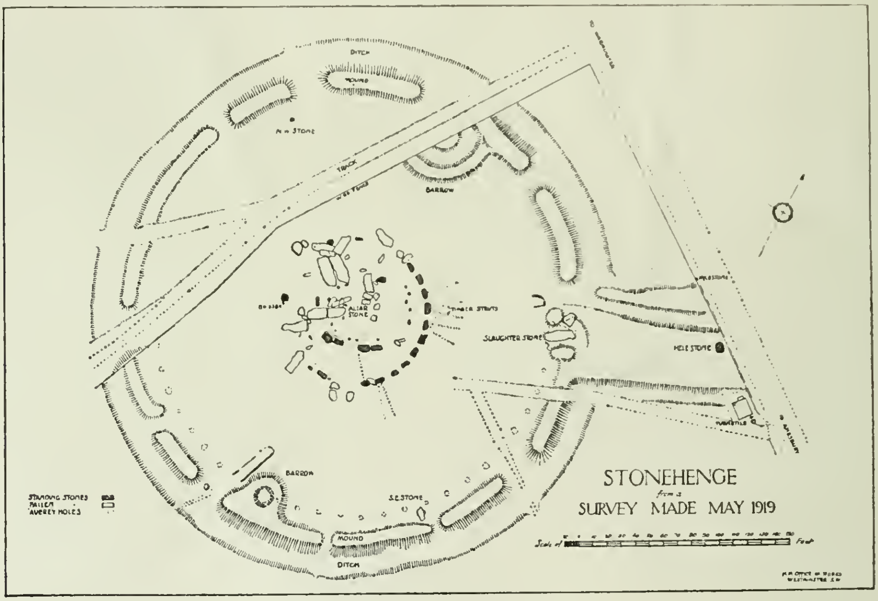


FIG. 1. SURVEY MADE IN MAY, 1919.

Part of the survey consisted in a detailed examination of each stone. Every crack, hole and fissure was carefully noted and recorded by means of sketches and photographs. As a result of this survey a report was prepared and recommendations were made to deal with stones Nos. 1, 2, 6, 7, 29 and 30, all of which were found to be in theoretically unstable condition. A copy of this report was presented to the Ancient Monuments Board for England and Wales, and after discussions it was decided to adopt the recommendations. It was also arranged that the Society of Antiquaries should nominate a representative to supervise the work of excavation which would necessarily be entailed. The Society undertook to bear the cost of any extra work involved in sifting and examining excavated material.

The first stones to be dealt with were Nos. 6 and 7, which were upright stones dependent for the maintenance of their position upon temporary timber struts. These stones are situated on the southern side of the outer Sarsen ring. These two stones are connected by a lintel, but the lintels to the adjoining stones, 5 and 8, have disappeared. These stones inclined in opposite directions, No. 8 to the east, at an angle of 7°, and No. 7 to the west (inwards), at an angle of 11°. No. 6 stone, which weighs about 20 tons, stood 13 ft. above the ground, and overhung its base by some 15 in. at a point 12 ft. above ground level. No. 7 stood about the same height and overhung its base by about 19 in. The lintel is approximately 11 ft. by 3 ft. by 2 ft. thick, and weighs about 5 tons. On the underside are two dowel holes which fitted over dowels in the uprights.

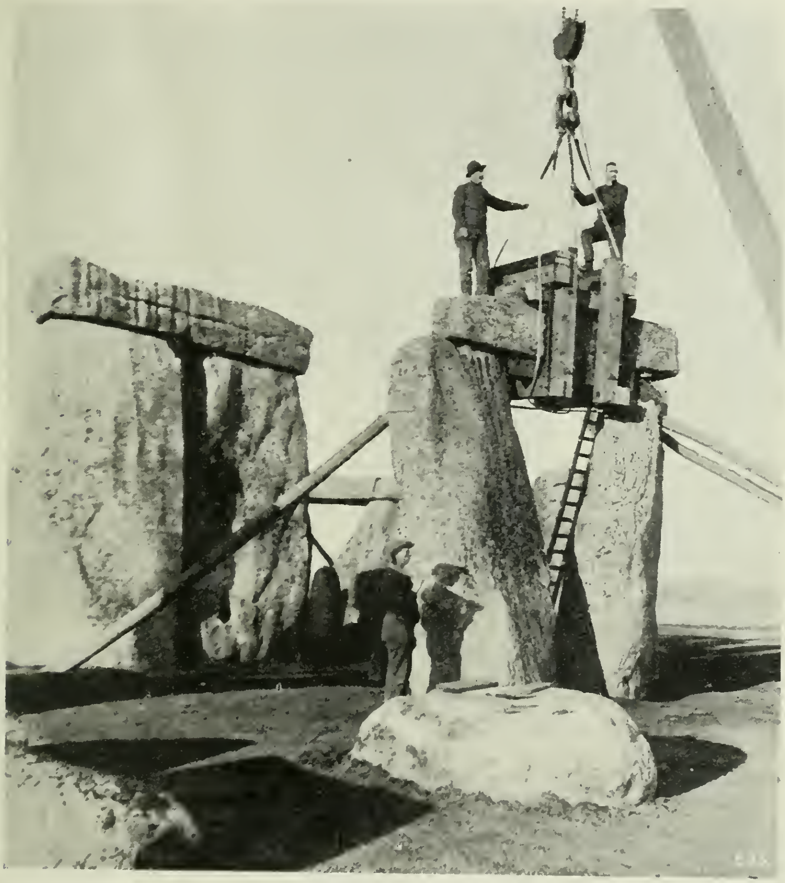


Fig. 2. Preparing Lintel for Removal.

The first job was the removal of the lintel, and for this purpose a cradle of 8 in. by 8 in. pitch pine timber was bolted round, thick felt packing being inserted between the timber and the stone to prevent marking. On November 27th the stone was raised from its seating, by means of a 7-ton hand derrick crane with a 40 ft. jib, and safely lowered. The next operation was to fit timber cradles around stones 6 and 7. Many methods of moving the stones were considered, but it was finally decided to adopt the principle employed in using the ordinary dumpy level, viz.: to support the stone from the ground by means of travelling screw jacks, which would enable the stone to be moved in any direction, and would also permit of excavations being carried out under it, and finally would prevent the stone from tilting sideways. The method adopted was to fix two 14 in. by 6 in. R.S.J., 20 ft. long, under each cradle, just clear of the ground and passing either side of the stone. These joists were connected by steel angle cleats to the cradle and four raking shores were carried down from the top of the cradle to the ends of the joists (see *Figs.* 3, 4 and 5). The four jacks were then placed under the ends of the joists.

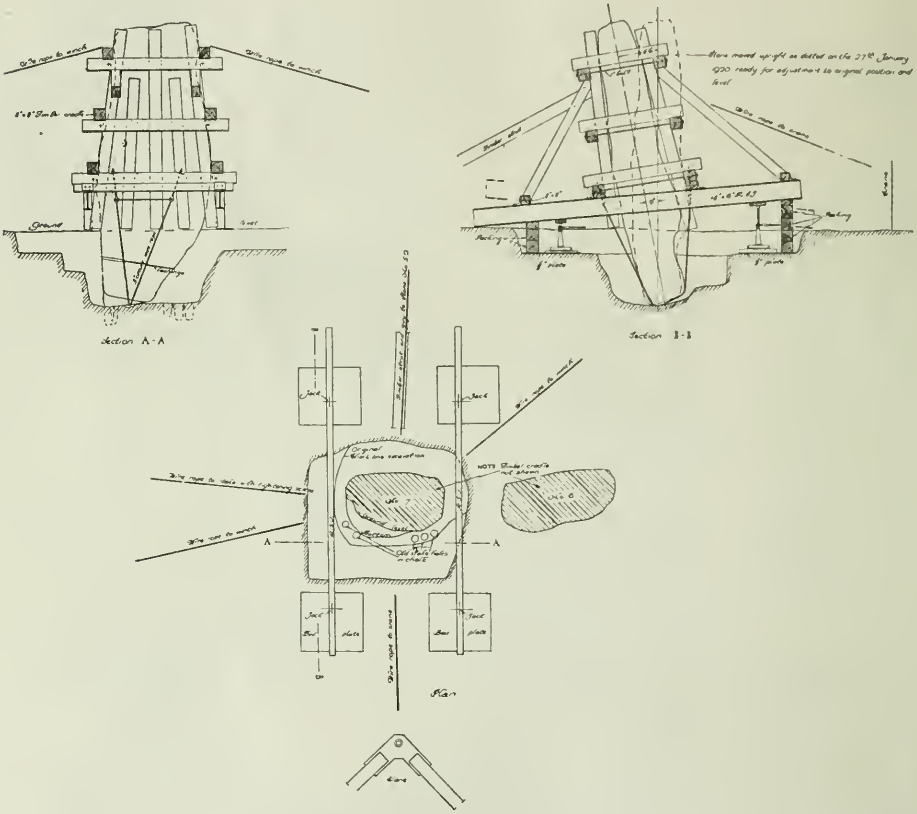


Fig. 3. Method of Moving Stone to their Original Position and Levels.

As already stated, a representative of the Society of Antiquaries was present during the operations, and in order to assist him in recording the exact position of each find the excavations around the stones were made with great care. The ground was squared into 1 ft. squares and the excavations were made 6 in. at a time from a fixed datum; in this way, by means of co-ordinates, the exact position of any finds could be recorded. These consisted chiefly of stone mauls, fragments of stones, and of Roman British pottery, and a few coins. Prior to beginning the excavations, however, the stone was stayed in four directions by wire ropes.

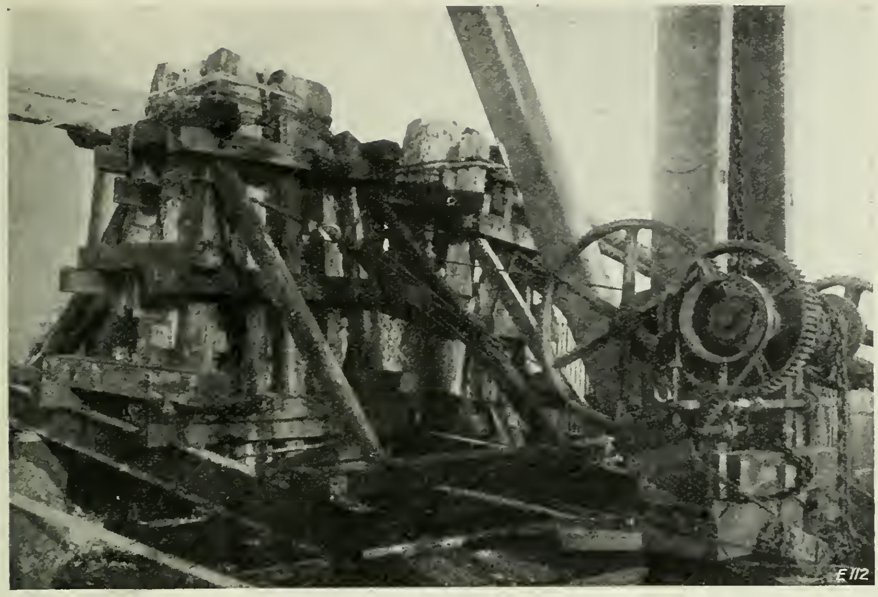


FIG. 4. STONE NO. 7 FROM S.E. AFTER BEING MOVED UPRIGHT, SHOWING TIMBER CRADLE ON STONE, AND EXCAVATION ROUND THE BASE OF STONE.

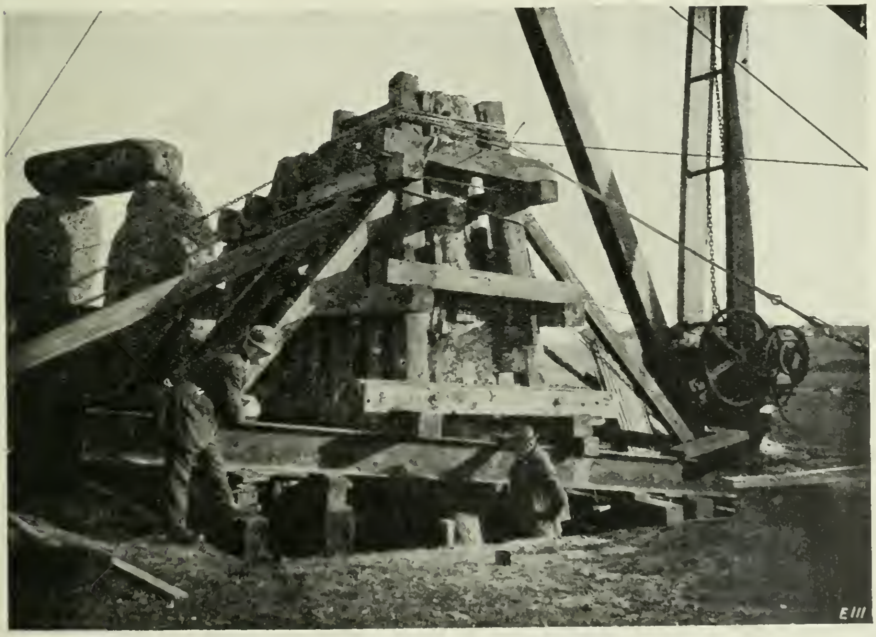


FIG. 5. STONE NO. 7, AFTER BEING MOVED UPRIGHT, SHOWING TIMBER CRADLE ROUND STONE RESTING ON STEEL JOISTS WITH SCREW JACKS UNDERNEATH USED IN BRINGING THE STONE UPRIGHT.

The excavation extended some 2 to 3 ft. back from the face of the stone, and beyond that four $\frac{5}{8}$ in. steel plates 4 ft. square were laid on the solid chalk as bed-plates for the jacks ; in one case concrete had to be used to give a firm and level foundation, but, for the most part, a bed of solid chalk was encountered 18 in. below the ground level. Before the stone was raised by the jacks wire rope slings were passed under the stone, through a channel cut in the chalk bed, and made fast on either side to the cradle. This, of course, was to prevent any possibility of the stone slipping through the cradle when it was raised.

By means of alternately raising the jacks on the inside and lowering the jacks on the outside, 1 in. at a time, No. 7 stone was brought back to a vertical position on January 27th, 1920. The ground was then excavated beneath the stone for a depth of 12 in., and a concrete bed 12 in. thick, reinforced with $\frac{5}{8}$ in. rods in both directions, was next inserted with the utmost expedition under the toe of the stone. No. 6 stone was then brought into the upright in a similar manner and the concrete bed extended under it, the two separate concrete beds being connected by projecting steel bars which were left for that purpose in the bed of No. 7. Before finally fixing the stones in their new positions it was necessary to ascertain that these were absolutely accurate. The evidence at the base was insufficient, but it will be remembered that on the top of the stones were dowels 4 in. high and 9 in. in diameter. Corresponding mortices, worn larger in course of time, were in the lintel ; it was essential firstly that these should coincide ; secondly, that the lintel should conform to the general line of the circle. To lift the lintel into position for a trial would be difficult, owing to its weight. A template was therefore made out of 1 in. boards with holes cut for the dowels. By this means the position of the uprights was exactly adjusted by traversing the jacks, and plumbings were taken on the four faces of the stones. Another template, 60 ft. long, and cut to the circumference of the outer Sarsen circle, whose diameter was 97 ft. 4 in., was then laid on the ground so that it just touched the inner faces of stones 5 and 10 (these being the adjacent standing stones to 6 and 7). Stones 6 and 7 were then finally adjusted, so that their inner surfaces just touched the template. A lintel is standing on stones Nos. 4 and 5. A dummy was made to bridge Nos. 5 and 6. In this way the continuity of the circle by means of lintels 4 and 5, 5 and 6, 6 and 7 could be observed.

In order that the dowels and dowel holes might fit, it was decided to make lead caps to fit over the dowels and fill the space between the dowels and the holes. These were most accurately made by taking casts of each dowel and dowel hole, and then making a lead cast of the intervening space (see *Fig.* 8). The cap for No. 7 stone weighed 170 lb., and that for No. 6, 69 lb. On March 17th the lintel was lifted back, and final slight adjustments amounting to fractions of an inch were made. The final operation of securing the uprights in their new positions was then begun. As a preliminary, the bases of the stones below ground were thoroughly cleaned down with water and wire brushes ; likewise the concrete bed. Concrete, reinforced with $\frac{5}{8}$ in. rods, was then placed on the beds round the stones and brought up to within 12 in. of the ground level at its outer edge, and 3 in. from the ground level against the stones. The lintel was then slightly raised in order that the caps might be fitted, No. 7 cap being inscribed, " May, 1920," and having a George V. shilling fitted in the top. The caps required a small amount of chipping before the lintel fitted down closely, and any interstice was

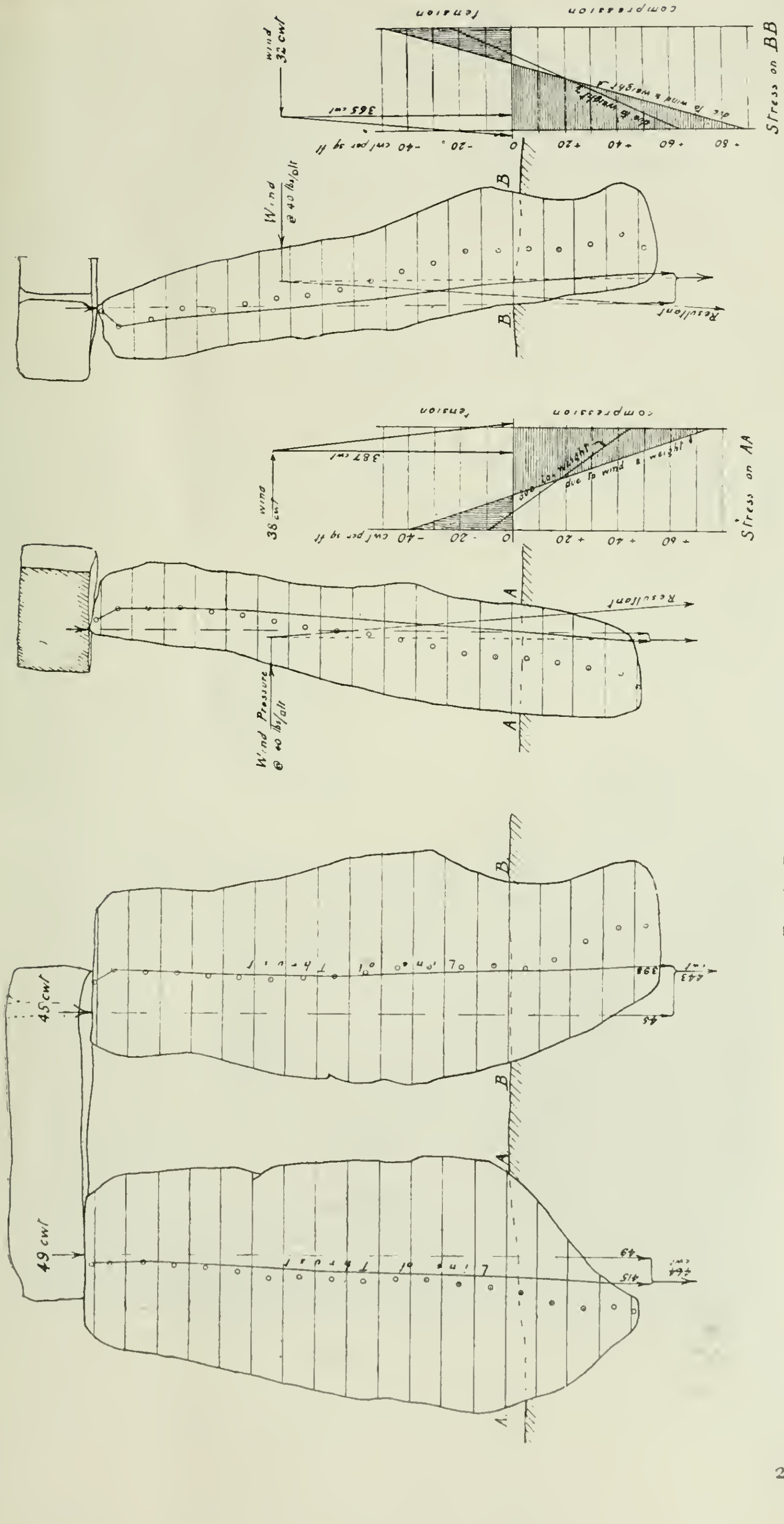


Fig. 6. Revised Stress Diagram for Stones 6 and 7.

caulked with lead. When the concrete had set, the wire rope slings were cut off and the ends turned down and cemented into holes left in the concrete for that purpose. On May 18th, the ground was returfed and the operation thus completed.

Stones Nos. 29, 30, 1 and 2, were treated in exactly the same manner. They presented more difficulty, however, as they were heavier and closer together.

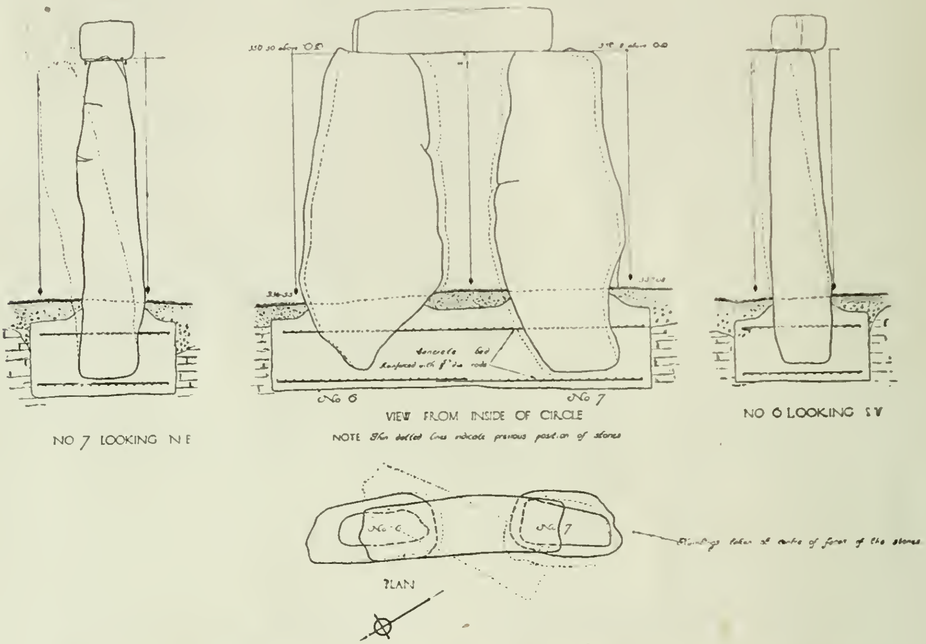
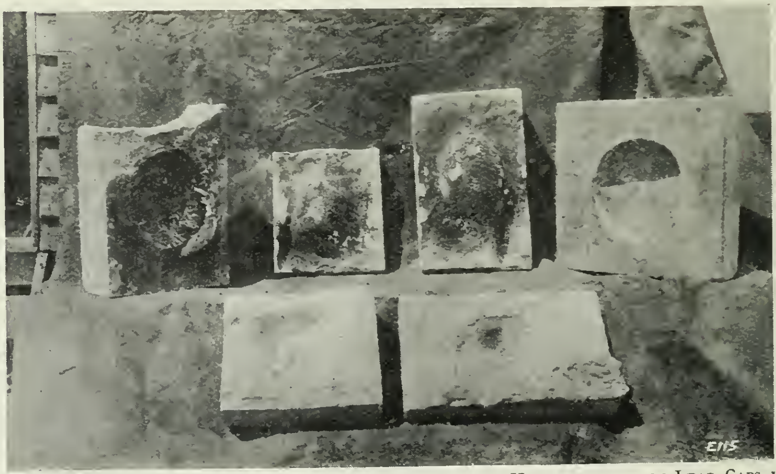
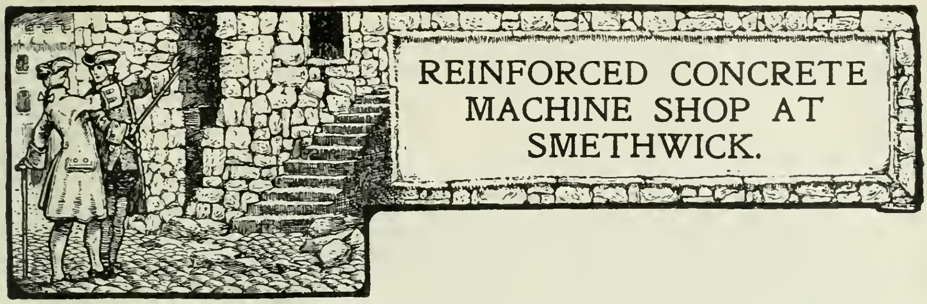

No 7 LOOKING N E
No 6
No 7
Concrete bed
Reinforced with ⅝" dia rods
VIEW FROM INSIDE OF CIRCLE
NOTE The dotted lines indicate previous position of stones
NO 6 LOOKING S W
No 6
No 7
Plumbings taken at centre of faces of the stones
PLAN

Fig. 7. Final Positions of Stones 6 and 7.

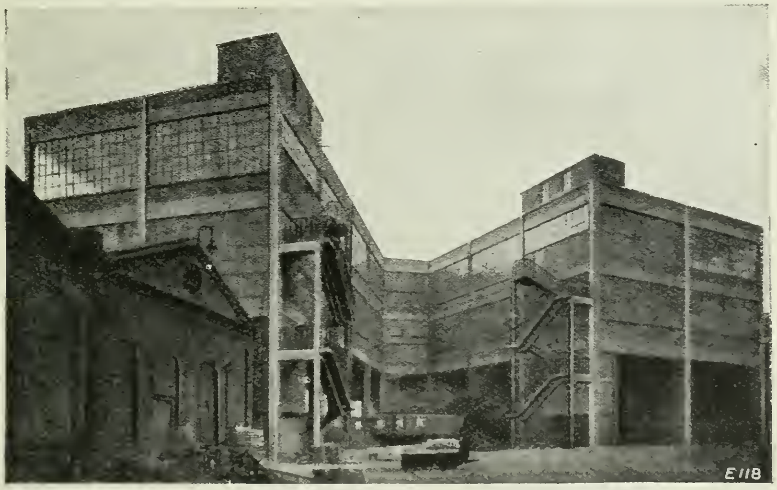


Plaster Casts of Dowels and Positives from them and Dowel Holes from which Lead Caps were Cast for Stones 6 and 7.



REINFORCED CONCRETE MACHINE SHOP AT SMETHWICK.

The building illustrated herewith has been erected over the steel storage yard of the Birmingham Railway Carriage Company, at Smethwick, in order to provide additional working space. Owing to its position in an already crowded portion of the Company's area, it was necessary that the site should still be available for storage purposes, and the whole of the building is therefore erected on columns. The distance between the columns supporting the building is necessarily large, and allows for railway tracks to be laid on the ground between the columns and under the building, where the storage yard is still being continued.



Reinforced Concrete Machine Shop at Smethwick: General View.

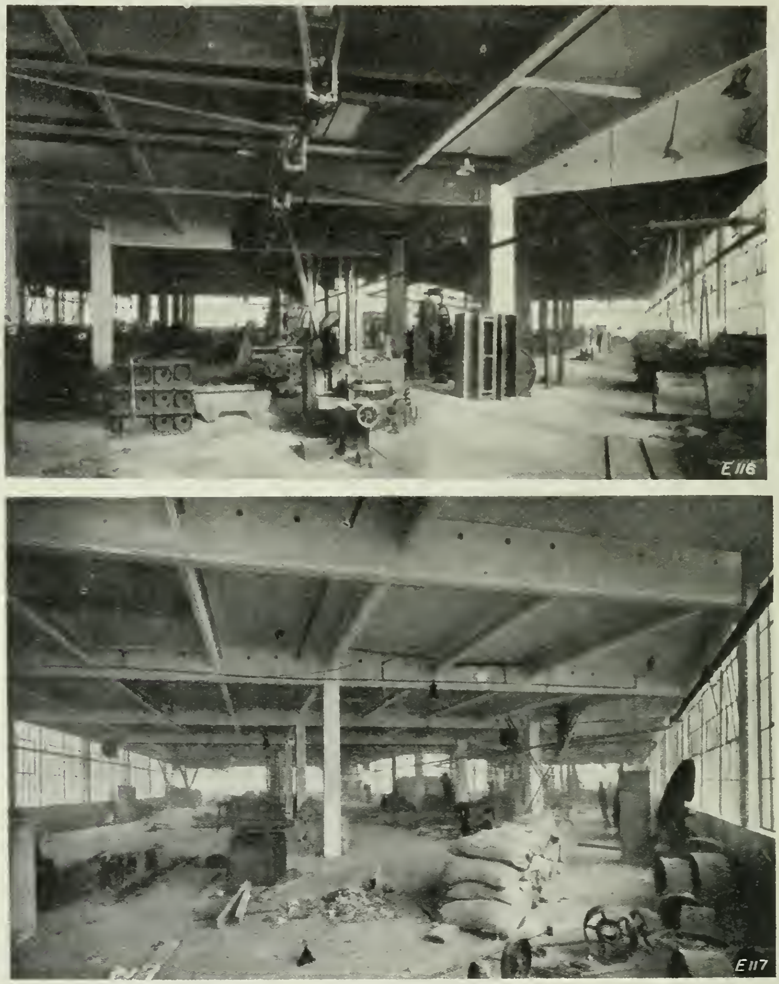
The building is built entirely of reinforced concrete on the "daylight" principle, the light being admitted through large window areas, separated only by the reinforced concrete columns, on all sides of the building.

The building contains two storeys, and the two floors and the roof are each constructed as reinforced concrete slabs supported on reinforced concrete beams and girders, which take the loads to the columns.

The first floor will carry a superimposed load of 2 cwt. per square foot, and has been especially reinforced to carry the heavy machinery which will be installed. The second floor is designed to take a load of 1½ cwt. per square foot.

The reinforced concrete columns which support the building are taken down to a depth of 13 ft. below ground level, and from that depth mass concrete piers are taken further down through the ashes which form the upper part of the subsoil to a firm clay bottom, which in some cases was only found at a depth of 30 ft.

The elevation of the building is relieved by two lines of brick dadoes, which run around the structure at the level of each floor. The brick dadoes are finished off with concrete copings, and the windows extend from this coping to the bottom of the reinforced concrete beam of the next floor.



First and Second Floors.
Reinforced Concrete Machine Shop at Smethwick.

Access to the building for the employees is by three reinforced concrete staircases. Materials are elevated by lifts installed in the corners of the building, while heavy machinery is hoisted up through a central hatchway in each of the floors, the lifting table being supported by the roof beams.

The building was designed throughout by Messrs. Peter Lind & Co., of 2, Central Buildings, Westminster, S.W.1, who also carried out the constructional work with their own staff of expert workmen.

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

THE CONCRETE INSTITUTE AT THE BUILDING EXHIBITION, OLYMPIA, WEST KENSINGTON.

THE official visit of the Institute on Wednesday, April 13th, was well attended and the members were conducted to various stalls of special interest. Mr. A. Alban H. Scott, F.S.Arc., kindly acted as chief guide. Mr. H. Kempton Dyson, M.C.I., gave an address on the same afternoon on the subject of "Building in Concrete," and showed on the screen some film pictures cognate to the subject of his lecture.

On Tuesday, April 19th, the President (Mr. E. Fiander Etchells) and the Council gave a luncheon in the Pillar Hall, at which were present, amongst others, as guests of the Institute :—The Most Hon. the Marquis of Salisbury, P.C., K.G., etc. ; The Right Hon. the Lord Riddell ; Sir Frank Newnes, Bart. ; Sir Ambrose Poynter, Bart. ; Sir John Thornycroft ; Mr. S. B. Russell, F.R.I.B.A., and Major Wightman Douglas, of the Ministry of Health ; Mr. Illesley (Ministry of Health) ; Sir Charles T. Ruthen, O.B.E., F.R.I.B.A., President of the Society of Architects ; the Presidents of the Institute of Builders and of the London Master Builders' Association ; Mr. H. Greville Montgomery, etc., etc. There was a large attendance of members and their friends. After the loyal toasts had been honoured, the Marquis of Salisbury proposed the toast of the Concrete Institute, to which the President responded, and the latter then proposed the toast of the Press, coupled with the name of Lord Riddell. After the toast had been acknowledged, Mr. A. Alban H. Scott gave an address upon the subject of "Science, Efficiency and Progress versus Stereotyped Building Acts."

On Saturday, April 16th, in the afternoon, a visit was paid to the new buildings being erected in Sumner Street, Southwark, for the Amalgamated Press, Limited, from the designs of Messrs. Herbert O. Ellis and Clarke. Mr. E. Lawrence Hall, M.C.I., took charge of the party. Further particulars of this building will be given in a subsequent issue.

RECENT ELECTIONS INTO THE INSTITUTE.

Honorary Member :—ROBERTSON, Sir Robert, K.B.E., F.R.S.
Associate Members :—BIDDULPH, Charles Hubert.
BURNS, Thomas Frederick.
CORYN, Allen Herbert.
HATTON, Albert Edward.
PEARCE, Harold Ellis Dallas (from Student).
Licentiates :— MANTLE, Christopher W.
MHATRE, Succaram Vassadeo.
Graduate :— WOOD, George.
Student :— COPSEY, Arthur George.

CONCRETE AGGREGATES—*continued.*

(36) **Flint (North Wales)** :—

General Description :—Lead mine crushed spar.

Source, and locality of same :—Various points in the county.

How obtained :—From large heaps.

From whom obtained :—Various lead-mining industries.

Is available quantity limited ?—Almost unlimited.

Is there any provision at or near source for washing or crushing ?—Already crushed and washed.

Price per cubic yard, and where delivered :—About 1*s.* 3*d.* at the mines.

Is composition uniform ?—Yes.

Kind of stone or coarse material :—Hard limestone and spar.

Shape of particles :—Angular.

Size of particles :—½ in. and down.

Impurities present :—None.

Source of information :—County Surveyor, Mold, Flint.

General remarks :—Very useful Concrete material.

(37) **Folkestone (Kent)** :—Compton Hill gravel and sand, containing 25 per cent. of loam. (R.C.B.).*

(38) **Glossop (Derbyshire)** :—Grit-stone inclined to be flat and dirty ; is not strong. (R.C.B.)*

I am enabled to publish the following reply to Mr. G. B. R. Pimm's letter which appeared in the last issue of this paper :—

"With reference to Mr. Pimm's letter, published in the April issue of CONCRETE AND CONSTRUCTIONAL ENGINEERING, I have not come across the river-bed deposits referred to, but should like to point out that the material in the refuse heaps is dangerous to the Concretor, not only from its contamination with clay, but on account of its mechanical weakness. I have found that after washing the sand to remove external clay many of the remaining grains can be broken in the fingers, owing, presumably, to partial disintegration, and the washed material thus forms a treacherous concrete aggregate. It is to be supposed that this state of partial disintegration does not exist in the river-bed material.

"Yours faithfully,
"R. C. BRANSTON.

"4, Lloyds Avenue,
"London, E.C.3.
"*April* 14, 1921."

STRESSES IN STEELWORK.

By S. BYLANDER, M.C.I., P. Chairman J.I.E.

Abstract from a paper read at the One Hundred and Second Ordinary General Meeting of the Concrete Institute on March 31st, 1921. The President, Mr. E. Fiander Etchells, was in the Chair.

I PROPOSE, in this paper, to deal with stresses in structural elements and connections for steelwork in building construction, and not with principal and secondary stresses in the main structural steel members.

Unit Load.—I am accustomed in my office to use a unit of weight of one kip (K), a term abbreviated from "*kilo-pound*," meaning 1,000 lb., for the reason that it will save probably 10 per cent. in the cost of the calculations. Also, it is simple, and reduces the work of checking, as only one unit is used instead of three, viz., tons, cwts. and lb. For small loads pounds are used, but only a decimal part of a kip, and therefore this need not be considered as a separate unit. One kip is used in calculations instead of one English long ton of 2,240 lb.

Basis Stress.—It will be found that in the majority of cases 10 kips per square inch is a safe unit stress for steelwork. It has therefore occurred to me that this unit of 10 kips could be adopted as a basis stress for structural steelwork, and that for varying conditions this basis stress could be multiplied by tabulated stress factors varying for pillars, beams, girders and elements of structural details. The advantage of adopting the idea of a standard basis stress for a particular material would tend towards simplicity, as the basis stress could be varied at will, while the *stress factors* would remain unchanged, and by this means, the engineer's requirements for the structure could be modified to suit the quality and cost of work desired and the safety factor permissible. Such variation in the basis stress would affect all the various calculations, without the necessity of specifying in detail for every one—simply by changing one figure only.

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* See previous issues for Index letters.

The stress factor will represent the increase or decrease of the basis stress due to—

1. Method of loading.
2. Shape and building up of the cross section and parts of structural member.
3. The mode of riveting bearings and abutting surfaces and connections.
4. Slenderness, flexure and stresses from other causes than intentional loading.
5. Grade of workmanship, etc., and others.

The stress factor is chiefly defined by theory, and can be computed theoretically under assumptions generally accepted in engineering practice. Some must of course be determined rationally from engineering and mathematical reasoning.

The stress factor for a definitely stated condition, therefore, is not variable, but represents a mathematical function, while the basis stress may be varied by reason of judgment in each case. Ten kips stress is safe for ordinary pillars in buildings, and might be constant and permissible from one up to sixty radii for the sake of simplicity. Above that limit, the stress must be reduced as determined by a slenderness stress factor. The shear stress on gross sectional area of webs for girders, and on rivets, could safely be set at ten kips, as a standard working stress for rough calculations. A narrow riveted compression flange under ordinary conditions, riveting and slenderness, could also safely be stressed to 10 kips per square inch of the gross area. Let us now take the tensile stresses, which, when only the gross sectional area is known for built up sections, and 20 per cent. reduction is made for rivet holes, the safe stress might be set at 14 kips or 1·4 of 10 K per square inch on the gross area, while the stress on the net area might be set at 17 kips (about $7\frac{1}{2}$ tons). In exceptional cases, where no secondary stresses have to be allowed for, I would even go as high as 20 kips per square inch on the net area. This might be considered the maximum allowable actual stress from all causes. You have therefore the simple and often admitted comparison that working compression stresses on the gross area should be calculated as only half of the working tensile stresses on the net area.

For tension only, the maximum stress would be twice the standard basis stress or the tensile stress factor would be two.

The basis stress of ten would be applicable to struts of moderate slenderness, even up to 90 radii, in favourable circumstances, when elements in compression such as stiffeners, plates and angles, shear on bolts and rivets and less important members or details are only roughly calculated.

For more accurate calculations, the proper stress would be ascertained through multiplying by the appropriate factor.

Limits of Stress.—When flexure and other secondary stresses occur, there should be two limiting stresses specified, the lower maximum for the principal stress only, and the higher maximum total stress being for primary and secondary stresses added together. The requirements being made in such a way as to permit an actual increase stress, if all the stresses have been fully ascertained and added.

Instead of putting a penalty on the designer who takes into account all conditions, a premium should be offered for thorough analysis of stresses. In other words, for rough calculations use a lower stress than for accurate calculations. For instance, a pillar with a slenderness of 30 should not be calculated for a stress of 13 K, unless it is ascertained that the application of the load on the elements of the sections is such that the actual total stress is not excessive owing to a flimsy section with unstiffened flange or locally increased stress due to application of the load. There is another principle on the problem of stresses in pillars, that the bending stress should not be added to the stress due to flexure for a very slender pillar in order to ascertain the total stress, as the maximum bending stress and the maximum flexural stress usually do not occur at the same level or point.

Beams.—It is indeed difficult to believe that the same kind and amount of stress will occur in all beams which are calculated for the same bending stress.

By the tabulation of suitable stress factors, working stresses could more easily be ascertained to suit more closely the actual conditions. Stress factors would be provided both for body and details, and elements of a structural member and a principal stress factor may be obtained by multiplying several subsidiary factors.

The stresses must be dependent on the quality and uniformity of the material, the quality of workmanship in the manufacture, and accuracy in fixing together the final structure.

Compression Generally.—Pillars, struts and girder flanges in compression are similarly treated, except that the reduction in stress for a girder flange is less than for a pillar having the same slenderness ratio. This is so because the flange stress in a girder varies from zero at ends, where freely supported, to a maximum at or near the centre of span, and therefore the flexure should be less.

Beam Connections.—I have analysed the stresses which may be expected to occur in the rivets for the connection angles or the cleats at the end of a beam, or what may be termed the "beam-end connections." The usual rough method of ascertaining the strength of a connection would be to take the strength of one rivet and multiply by the number of rivets, and the product would be assumed to represent the total load the connection could carry; but this is obviously not safe for all connections, as the actual strength of a standard beam connection may be as low as one-quarter of the above.

The assumptions made for calculating the strength of the connections are, like other assumptions for riveted work in the theory of structures, only approximately correct. It should never be forgotten that assumptions are usually based on perfections which do not exist; however, they are the best assumptions which we have so far succeeded in finding. It would be interesting to have tests made to compare the actual strength of connections with those calculated. I think, however, that the calculated strength is quite near enough for practical purposes and has the advantage of being based on simple assumptions. The foregoing remarks apply to the leg riveted in the shop to the beam web.

In calculating a twisting moment it has been assumed that the outstanding leg of the connection is freely supported at the root of the angle and that the rivets or bolts through the outstanding leg are not subjected to tension. Rivets are however not supposed to be calculated to resist tension, and further the back-set to these rivets is so great that the angle will deform before any material tension is developed in the rivets or bolts.

Where only one connection is used on one side only, the rivets in the outstanding leg will be subjected to twisting shear as well as the leg riveted to the web of the beam, and must be calculated in the same manner. Where two connection angles are used the twisting moment in rivets in the outstanding leg may be assumed for practical purposes as balanced.

Riveting.—The remarks for pillar riveting apply also to girders. The pitch near the end should be smaller than the pitch on the centre. In good work, and for conditions applicable to the usual calculations, it is of course necessary that the proper pitch and distance between rivet lines (set) should be properly arranged. The minimum and maximum rivet pitch for certain size of rivets and certain thickness of plates should be specified, and the placing of rivets in a girder will also, of course, have to be made suitable to transmit the flange stress. Where local loads are applied, the shear on rivet due to such load must be calculated when computing the rivet spacing for bending. The inset for rivet or the edge distance for the plate is of great importance.

The following are suggested as suitable stresses :—

SINGLE SHEAR.

Rivets (shop)	12 kips
Rivets and turned bolts (field)	10 ,,
Rough bolts (field)	8 ,,

BEARING.

Rivets (enclosed)	30 kips
Rivets (one side)	24 ,,
Rivets and turned bolts (field)	20 ,,
Rough bolts (field)	16 ,,

Before concluding, I would again like to refer to the advantage of using pounds in the calculations for steelwork in place of tons, cwts. and lb. The pound is a better unit than cwts. for small loads, such as superimposed loads on floors, the weight of the floor itself, and the small additions or deductions to the total load which have to be made on account of different construction of materials used. For instance, if the superimposed load is 100 lb. per square foot, and the floor finishing weighs 25 lb. per square foot, the floor 40 lb., and the beam casings and steel beams, etc., average in weight 50 lb., the sum of which is the total load to be used for the calculations of the beams and girders, it is obviously more convenient to calculate in pounds, than in cwts. and fractions of cwts. I may instance a case where a pound is simple to use for calculating the weight of concrete. The weight of a concrete beam is approximately 1 lb. per square inch of sectional area per foot run, assuming the concrete weighs 144 lb. per cubic foot. The weight of a concrete slab on the same basis is 12 lb. per square foot per inch of thickness. Steel weighs 3·4 lb. per square inch per foot run, etc.

I would also like to refer to the method of taking out loads and recording them in the calculations. Simplicity and system, to my mind, are of the greatest importance in order to obtain accuracy and speed for big jobs.

DISCUSSION.

Mr. W. J. H. Leverton, Licentiate R.I.B.A., asked for information upon the latest practice with regard to the factor of safety. For a long time one-fourth had been taken, but at present, when materials and labour are so expensive, it is necessary, for the sake of economy, to sail as near to the wind as possible, and generally the advice given is to take one-third. With regard to the stress on steel joists embedded in concrete, the author had spoken of stressing them up to 20 kips, which, in round figures, was about 9 tons, and of the strength which was gained by the lateral support which the concrete gave. Is that 20 kips, or 9 tons, limited to the compression of the flange or does it include the tension of the flange as well, because although the joist is strengthened by the concrete as regards compression, it gains no strength in tension, unless, of course, the slab of concrete is very much deeper than the joist itself.

Mr. E. Lawrence Hall, referring to the stress in the upper flange of a girder or joist, said if that had any length of span certainly a less stress should be put into it than the ordinary standard stress, but the L.C.C. regulations are silent on that subject, and when these are revised something ought to come in in this connection.

Mr. Gordon Young, M.C.I., referring to gusset plates to the stanchions, asked the author's opinion as to allowing sufficient rivets to take up the whole of the stress on the stanchions. Some engineers consider that if the gusset plates and angles are riveted on and then the hinges planed, and if the workmanship is good, it should not be altogether necessary to provide the full number of rivets as required by the calculations. He also asked for some information regarding lattice stanchions. He believed that Mr. Bylander, in Selfridge's building, had advocated the use of channels with lattice bars on the upper lengths, in order to keep the section the same throughout the entire length of the stanchion. It is somewhat difficult to say the amount of stiffness one should use, especially in very deep lattice girders where the loads are not excessive.

Mr. Allan Graham, A.R.I.B.A., said that shop drawings made a very great difference, not only with regard to the carrying out of the work, but as regards cost. When everything was being done to reduce costs we cannot really afford to take too much account of secondary stresses. With regard to Mr. Leverton's remarks as to the tension of the bottom flange, he did not think tension came into consideration. When dealing with beams embedded in concrete, it is very useful to be able to look up the L.C.C. tables, find out the length and find the stress. The author had also said in the paper that the bending stress should not be added to the stress due to flexure for a very slender pillar in order to ascertain the total stress. Here again the speaker was prepared to stick to the L.C.C. tables, unless he found that Mr. Bylander's would give better results.

Mr. Lawson S. White, A.M.C.I., asked the author's opinion as to the desirability of standardising clearances of rivets. With regard to eccentric loading on columns, if a girder were carried by two brackets, one on each flange of the stanchion, so that the girder would bear on both, would the stanchion be considered eccentrically loaded in the plane of the axis of the beam? Would the rivets in the bracket nearer the centre of the girder be more heavily stressed than those in the further bracket ?

Mr. A. E. Marshall, M.C.I., referring to the question of rough bolts, asked Mr. Bylander to say what he allowed to be done in practice in the case of rough bolts, whether he allowed that any ordinary bolt could be used, because the usual bolts supplied would be threaded very often for nearly the whole length of the shank. Would he specify that rough bolts should have less thread, and should be accompanied by a washer, so that the ends could be screwed up ?

The President, speaking with regard to clearances, said that for years the Engineering Standards Committee had from time to time discussed the question, and there was a division of opinion as to whether the bolts should be standard or the hole. When that controversy was settled the rest would easily follow. There were one or two parts of the paper where it might be advantageous to make some correction. The question of the standard of stability would require long and careful consideration. Suggestions have been put forward which would be considered by many engineers and time alone would tell the extent to which they had been adopted. As to the paper itself, the author said on page 3 that the unit of weight which he referred to as a kip was legalised in Great Britain by Act of Parliament, but under a different term, namely the "millal." The speaker was not quite sure, but he believed that about May, 1907, he himself made the suggestion that 1,000 lb. should be used as a unit, as it was found to be convenient in reinforced concrete work. The "cental," 100 lb., was legalised by Act of Parliament in 1878. Prior to that date there were many standards of cwts. in use by different nationalities, and it was thought desirable to have a new standard. Therefore, the cental was legalised, but prejudice had been much too strong and the cwt. of 112 lb. still persisted in this country. He, therefore, introduced the unit of 1,000 lb., and gave it the name millal. Those who had to make calculations would desire to use a unit which would result in small numerals, and the use of the unit of 1,000 lb. was a means of avoiding large numerals. In the paper Mr. Bylander had suggested the word "sets" instead of "pitches," but the speaker preferred the term "mid-set" rather than "angle-set."

THE LECTURER'S REPLY.

Mr. Bylander, in replying to the discussion, said he rather feared they would not adopt the lb. as a unit because the figures would be too big. Mr. Leverton had referred to the factor of safety, but he was not prepared to suggest whether it should be one-third or one-fourth. A definite rule as to stresses and as to the factor of safety to be adopted was very uncertain, and he thought it better not to lay down hard and fast rules. The paper set out to explain that it was not so much a question of theory as to what stress was used, but rather a question of the conditions. It should be left to the engineer to fix the exact stress, but the factor generally adopted, namely, one-fourth, was the wisest thing. Dozens of tests had been made on full-sized columns, and it was interesting to notice that a steel which would stand 60,000 to 70,000 lb. per square inch tensile would only stand about 35,000 lb. compression. Under the best conditions a factor of safety of one-third should be adopted, and an even greater one if friction be taken into account. With regard to the stresses in steel, he was not very much in favour of calculating that the concrete would act as a compression flange or that beams embedded in concrete would act as reinforced concrete. If it were desired to take advantage of the concrete as a compression member it would be better to use bars and to do away with the steel at the top altogether. His reply to the question would be that he referred to the stress in the bottom flange as well as the top flange. Referring to the question of the gusset plates on pillars, his own suggestion was that there should be no limit at all as to the number of rivets to be placed in the gusset plate; there should be no fixed rule that the rivets in the gusset plates should be a certain percentage. It should be dependent on conditions. A point to be emphasised, however, is that at the end of a pillar, either at the joint or at its base, it is advisable not to stress each individual thickness of plate in the main section of the pillar to the same extent as in the pillar itself, because at the end the plates are not firmly held together. With regard to using lattice columns, in selecting the sections of columns, as well as other sections, market conditions must be taken into account. With regard to the stiffness on plate girders, Mr. Bylander did not know of any definite rule or any simple method by which the section of the stiffener or the position of the stiffener could be determined, except, that as a rough rule, they must have a stiffener when the height of the girder exceeded 60 times the thickness of the web. As to Mr. Graham's remarks, he agreed it was no good applying beautiful theories if they could not produce the buildings their clients would pay for. The cost was very important, but should not be the first consideration; safety should be considered first, and therefore it was useful to have some standard to go by such as had now been laid down by the authorities in most of the large cities. Regarding the reference in the paper to flexure and bending stress, what was meant was that if, say, a slender pillar were calculated, with slenderness up to 140 or 200, for a certain ratio, and there was a bracket, say, on the floor level, carrying crane work, and the maximum stress permissible was obtained at the free end, or if fixed, at both ends, the bending stress or flexural stress would occur at the top of the pillar, and there was very little stress due to what he incorrectly called flexure. Inflection would perhaps be better. What was meant by flexure was the bending stress due to slenderness, and bending stress should be the flexural stress due to eccentric loading. Mr. Lawson White had referred to the question of clearances. As far as he could understand, the general practice was that the diameter of rivets should be referred to as nominal. When they referred to a $\frac{3}{4}$ in. diameter rivet it was neither the diameter of the rivet nor the diameter of the hole, because a great number of firms and shops adopted the practice of using a rivet which was less in diameter than the nominal, and therefore when the diameter of a rivet was specified it should be the diameter of the rivet before driving. As to the diameter of the hole that meant the finished hole after drilling. Clearances are not at all standardised. The limit generally adopted is $\frac{1}{16}$ in. between the actual diameter of the rivet before driving and the actual diameter of the hole after drilling. Unfortunately, a good many firms adopt a clearance of $\frac{1}{8}$ in., but in very few cases would the rivet fill the hole completely if such clearances were used. As to the question of whether the brackets on two sides of a column were equally stressed in supporting a beam running at the side of it, that was a question of engineering judgment. It is very bad practice to assume that one beam can have two individual bearings, and that the load can be calculated in any particular ratio. If one bracket were a little lower than the other, one was taking the whole of the load. With regard to bolts, under no circumstances must bolts be used with the whole length threaded. Ordinary bolts are very unreliable. At the same time, in heavy work the turned and fitted bolt is more reliable than the rivet. He agreed with the President's remarks as to the words kips and millals. The suggestion that mid-set should be used instead of angle-set was also a good one, and he himself would be quite ready to adopt it.

CONCRETE COTTAGE BUILDING.

NORWICH HOUSING SCHEME.

To whatever part of the country one turns, concrete cottages are to be found. It would really seem that eventually the advantages of this method of construction are being appreciated, and that those who have worked so persistently in overcoming apathy and prejudice are at last feeling that they have not, after all, been sowing on barren soil. Of late an additional impetus has been given to concrete cottage building by reason of the lack of skilled labour, and at Norwich, whose rates rank among the highest in England, it is particularly essential that the Corporation should exercise every means within its power to produce cheap houses.

Despite the high rates the Norwich City Council have embarked upon an ambitious programme, which includes the acquisition of some 416 acres, and the erection of 1,200 houses. The first site to be developed was the Angel Road site, a layout plan of which is shown in *Fig.* 1. It will be seen that the development is on thoroughly up-to-date lines, the houses being generously spaced and pleasantly ranged round closes and *cul-de-sacs*, instead of being huddled cheek by jowl. If there is nothing else for which the country should be grateful to the Government in the matter of housing, there is at least this : the fact that they are largely responsible, through their technical officers, for inculcating new ideas in estate development.

Although there is no marked shortage of bricks at Norwich, many of the houses are being built in concrete on the Angel Estate, a Winget Standard Blockmaking machine being used. On the Mile Cross Estate 100 houses are to be built on the Dorlonco System, a system of steel frame and expanded metal. The Duo-Slab method, which was fully described in this journal in connection with the Leeds Housing Scheme, is also to be employed ; likewise the Calway. The houses made with the Winget blocks, eight of which were included in the first twelve which were opened by the Lord Mayor of Norwich on October 20th, 1920, are built with a 4½-in. inner and outer skin and a 2-in. cavity. On certain houses these concrete blocks are used to form a plinth and for quoins. The ground floors of these houses are of concrete and the upper floors are of timber. The houses are roofed with pantiles, a very pleasant roof covering, where there is little cutting, and one which enables a low pitch to be maintained, thus economising in roof timbers. The chimney stacks are built of Norwich bricks, while the breasts and party walls are of Flettons. The sculleries are pointed and limewashed, the other rooms being plastered and distempered. All internal joinery, with the exception of the window frames, is treated with Solignum, the window frames, both internally and externally, are painted white. The houses are lit by electricity, the distribution being by means of overhead cables attached to the chimneys. The service cable is brought down the chimney in a specially constructed duct built into the stack.

The question of communal heating received consideration, but unfortunately the grave necessity of keeping down capital expenditure rendered the outlay which such a service would entail, impossible. The whole of the work on the Angel Estate, including the making of new roads, laying sewers, the erection of fences, etc., and the houses, is being carried out by direct labour through the City Engineer's Department, Mr. Town, the deputy city architect, being immediately responsible to the City Engineer, Mr. Arthur E. Collins, M.I.C.E. Professor Adshead, F.R.I.B.A., is the consulting architect for the whole of the Corporation housing schemes. The amount agreed to by the Ministry of Health, on April 15th, 1920, was £850 per house. On May 1st, however, it will be remem-

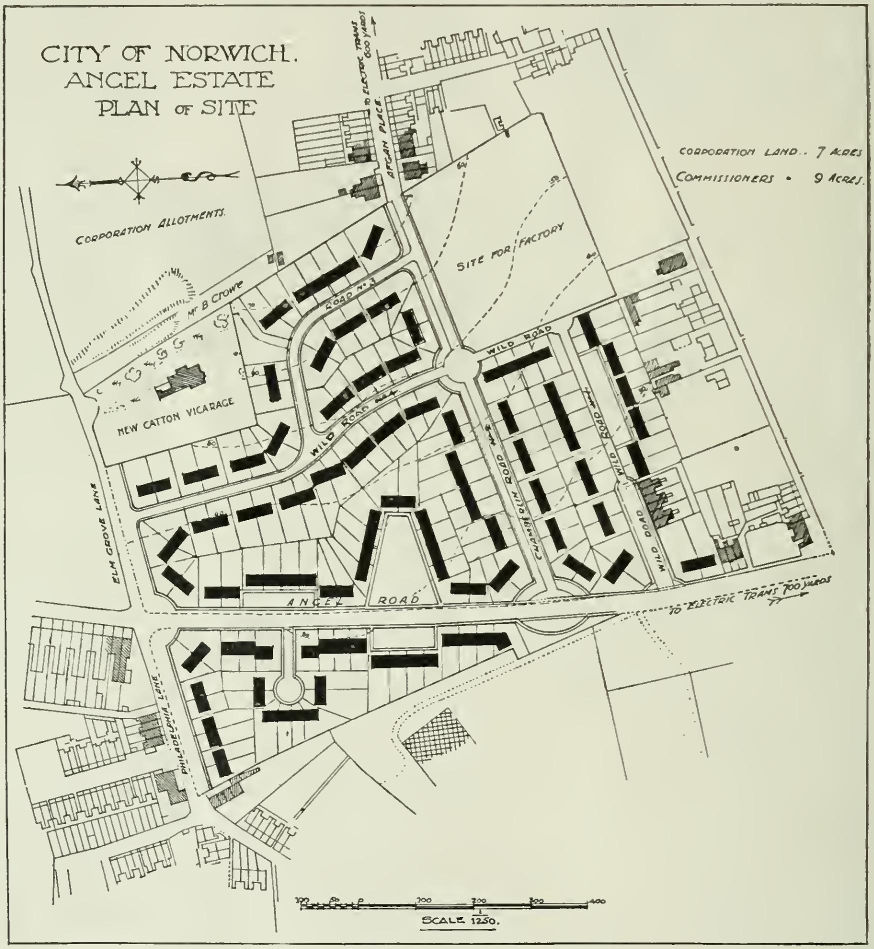


Fig. 1. Layout Plan, Angel Estate.

bered that there was a general increase in the rates of labour in the building industry, the price of materials also rose considerably, although there has been a subsequent welcome fall in certain of them.

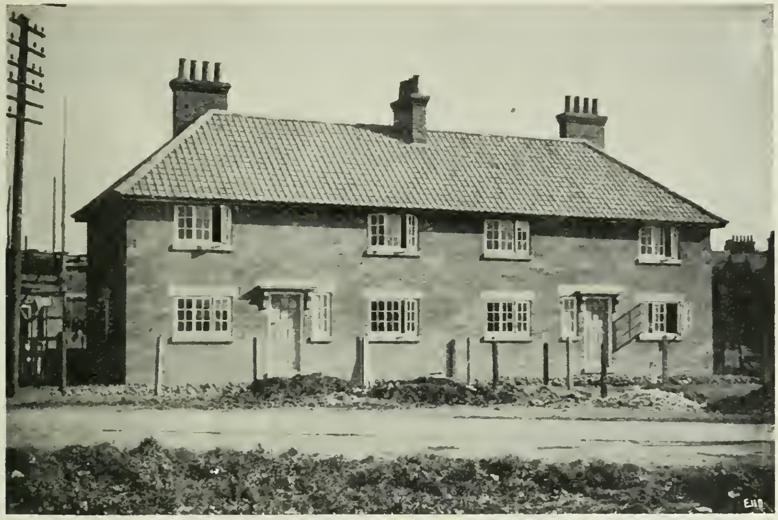


Fig. 2. A Pair of Completed Houses, Front View.
Norwich Housing Scheme.

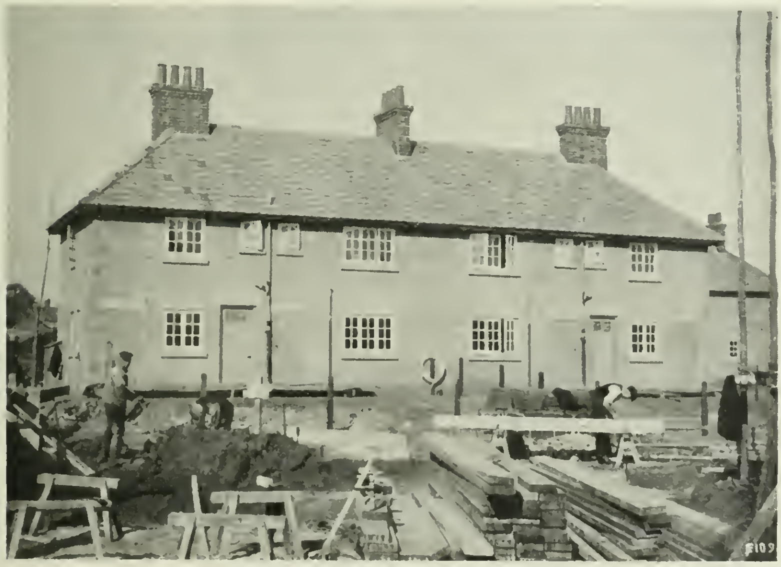


Fig. 3. Back View of above Houses.
Norwich Housing Scheme.

Fig. 2 shows a finished pair of semi-detached houses built with Winget blocks. Although the elevation is simple, it is extremely pleasant. The windows and doors are well proportioned, and the overhanging eaves throw a bold shadow which overcomes the bareness so often apparent in houses of this kind where

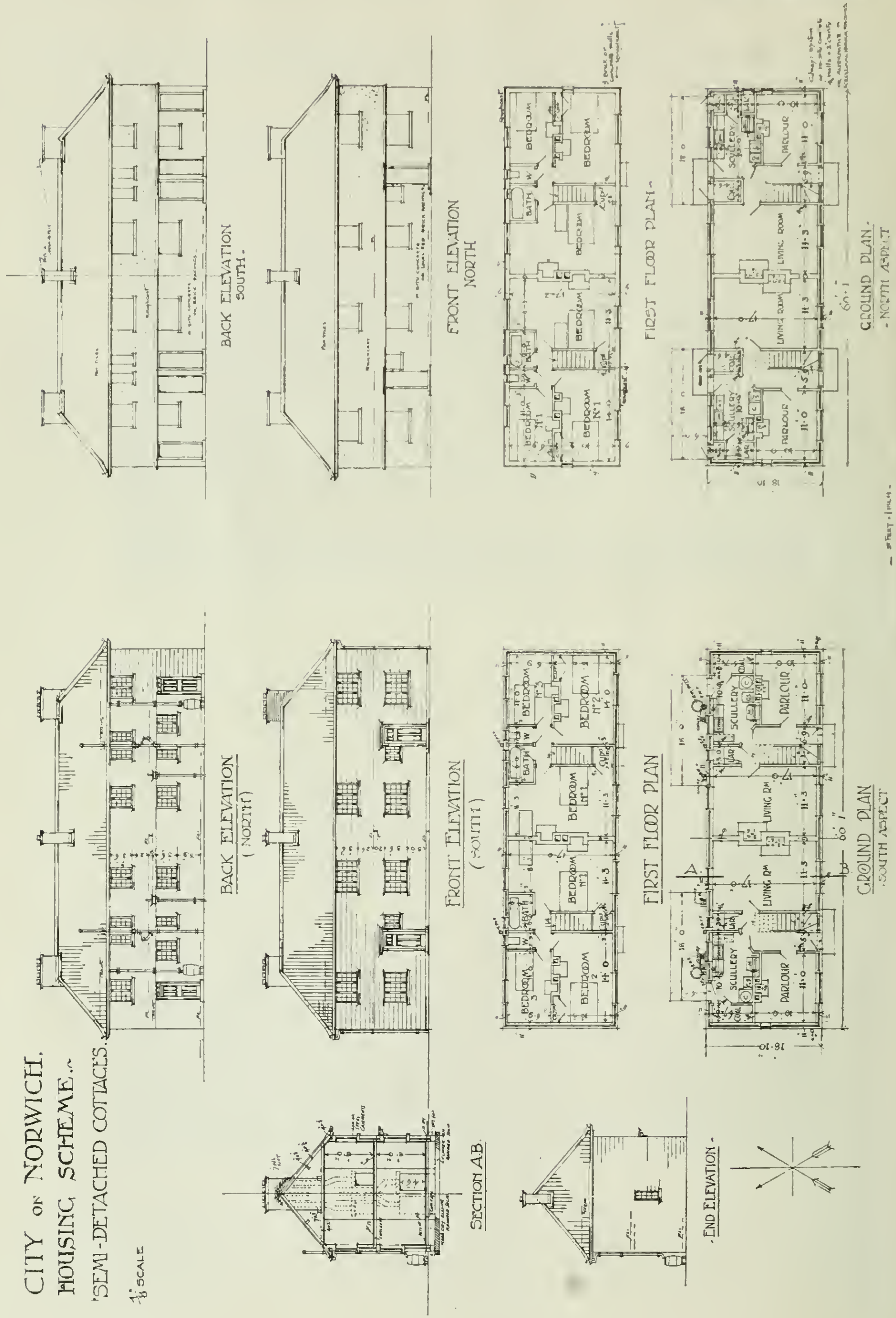


Fig. 4. Plans and Elevations for a Pair of Cottages.

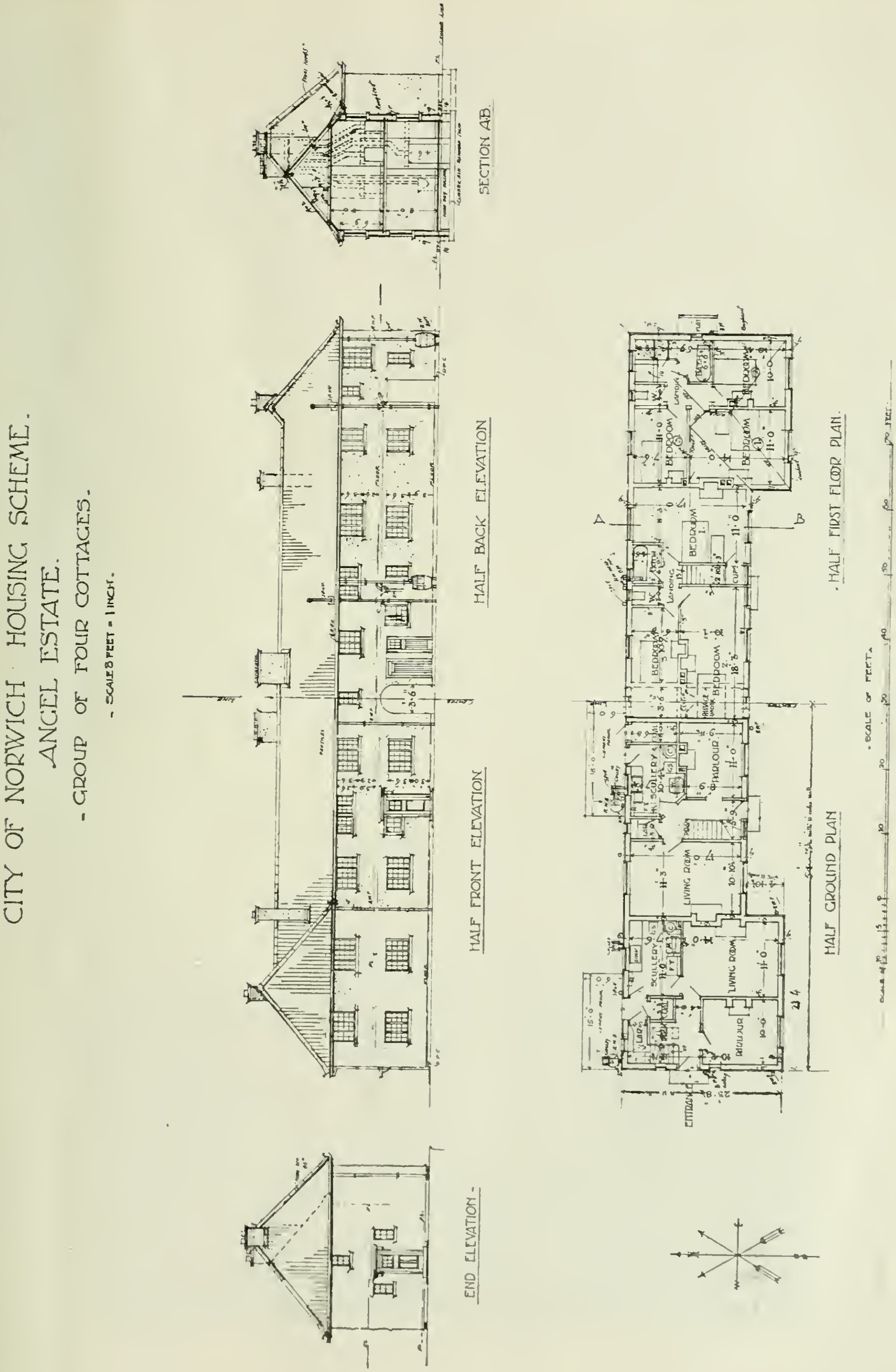


Fig. 5. Plans and Elevations for a Group of Four Cottages.

there is no cornice and only a small projection of eaves. The contrast between the grey walls and the red pantile roofs is very satisfactory. *Fig.* 3 is a back view of a similar pair. The overhead electric light cables can be seen attached to their insulators on the middle chimney stack. *Fig.* 6 is a corner block, one of the first to be completed and occupied. It will be seen that the house on the left is of brick-work. The effect on this site is mostly obtained by grouping, and by variation of material. It shows, in fact, how a unit, simple in itself, if properly used, can produce a whole which appears neither monotonous nor parsimonious. A plan of the pair of cottages is shown in *Fig.* 4. The planning is direct and straightforward, yet everything has received proper consideration. In the scullery there is space for copper, gas cooker and mangle ; pram space is provided under the stairs and the two chief bedrooms have wardrobe cupboards. The elevations show an alternative of concrete blocks, or of walls built with the lower part of *in situ* concrete, on the Calway system (two 4½ in. skins and a 2 in. cavity), or facing bricks, and the upper part of 9 in. brickwork rough-coated. *Fig.* 5 shows plans, elevations and section of a block of four with a central passage. Both types of houses are of the parlour type, and the rooms are of generous proportions.

Norwich has been active in raising money by local Housing Bonds. Already before the close of last year over £92,000 had been obtained by this means, and £200,000 by other sources, towards the cost of the housing scheme. It is not the intention of the Corporation to carry out all their work by direct labour, and on the Mile-Cross Estate a contract has been let to Messrs. Fasey & Co., Ltd., of Leytonstone, for the erection of the 100 " Dorlonco " houses. It will be appreciated from what has been said that Norwich constitutes one of those interesting schemes where brickwork and concrete may be compared side by side, not only that, but one system of concrete may be compared with another. In this way faults can be noted and improvements made.

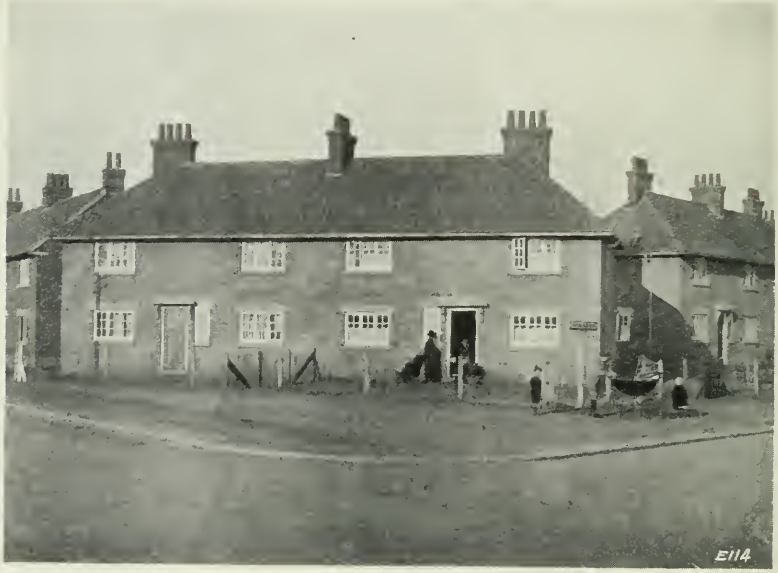


Fig. 6. A Corner Block.
NORWICH HOUSING SCHEME.

SOME CONCRETE HOUSES BUILT AT FOLKESTONE IN 1870.

By W. H. POPE, M.R.S.A.

THE Marine Crescent, Folkestone, is situated facing the sea on the Lower Promenade, and near to the Pleasure Pier. It was designed and built by John Pope & Son, Architects and Builders of that town.

The Crescent consists of fourteen houses, the houses at each end being much larger than the rest. As is seen from the illustration the houses are arranged in the form of the arc of a circle, each house radiating to a common centre.

The erection of the houses was commenced in the year 1870, and they were finished by another builder a few years later. It is claimed that this is the first instance in which Portland cement concrete was used in this country, or in any other, for the erection of dwelling houses, and as such it stands out as an excellent example of concrete work even at the present day.

Each house has bay windows on four floors, the windows on the fifth floor and in the mansard roof being set back to the straight line as drawn on plan. This projection from the line of the elevation naturally caused more work in arranging the iron shuttering, but the result was a more pleasing front and larger and pleasanter rooms. At the time of erection the Crescent naturally attracted much attention and comment, some of the local papers describing them as "mud houses which they thought were very unique." The houses have proved warmer and drier than a brick house. They also possess greater stability, the walls being practically one solid block, and they do not rock under the influence of heavy gales as most brick houses do in exposed situations.

The method of erection was by means of iron shuttering with angle iron riveted around the edges and across the centre to stiffen the plates and keep them from getting out of shape; the side angle iron had a hole drilled in each corner to receive a $\frac{3}{8}$-in. bolt and nut by means of which it was fixed to uprights or standards which were shaped on section 3 sides of a square ⊓, having a series of holes in the sides to receive the $\frac{3}{8}$-in. bolt by which to fasten the shuttering. The shuttering was raised as the work of filling in the concrete progressed. The standards were 10 ft. long, which was equal to the height from one floor to the top of the joists on the next floor—this enabled the concrete to be filled in up to the level of the next floor, the last layer of concrete having embedded in it a series of rough boxes to receive the ends of the joists which stretched from party wall to party wall.

The shuttering was then, together with the standards, taken away and re-erected on the next floor joists after they had been placed in position.

The partitions of the rooms were formed in a similar manner, of concrete, but 6 in. in thickness; these were carried up through four floors in order to make the rooms more sound-proof and substantial.

The window frames and outer door frames were placed in their positions, wood blocks being inserted in the concrete to which they could be fixed later. Sufficient shuttering was used to form the walls right round each house, and the concrete was allowed two days to set before the shuttering was removed and re-erected. It was possible to erect to a height of 2 ft. 6 in. of wall at a time.

The shuttering for the Bay windows was made in sections, the window frames being placed in position and the reveals of the openings formed by boarding, cross strengthened to retain the concrete; these were afterwards taken away and used again. Wooden bricks 4″ × 2″ were embedded in the concrete to receive the door jambs, and in side walls to which the staircase stringing was afterwards fixed. At a later date when it was found that a breeze concrete brick would allow of a nail being driven into it these were substituted for wood.

The main walls were 14 in. in thickness and were made of Portland cement concrete in the proportions of 1 : 1 : 9 (or nine parts shingle, 1 part sharp sand and one bag cement). These ingredients were shot upon a banker and turned over and thoroughly mixed dry before the water was added.

The walls were solid and packed or filled with hard blocks of chalk, as follows :—

Concrete Houses, Marine Crescent, Folkestone.

When the shuttering was fixed and ready to receive the concrete, this was filled in to a depth of 3 in., and upon this layer lumps of chalk or burr (a very coarse rock) about the size of a loaf of bread were placed. More concrete was then filled in and carefully worked around the blocks to insure of there being no cavities. When the chalk was covered with about 2 in. of concrete, more chalk blocks were inserted and the above procedure repeated right up the height of about 60 feet. The surface was finally rendered with cement and sand in the usual way.

The front and back steps were also formed of cement and are in the same condition to-day as when made fifty years ago.

There was also formed at the same period a flight of about 150 steps leading up the cliff; these have been in constant use by visitors to the town, and are still in excellent condition and show no signs of wear.

MEMORANDUM.

Concreting River Banks.—A useful method of dealing with river banks subject to being broken away is to take equal proportions of sand and shingle in a dry state and to each six parts add from half to one part Portland cement, thoroughly mixing the stuff. This is then filled into rather open textured bags, sewing up the ends so that they shall be fairly square, and the bags are laid as a wall in close order so that the joints between the bags are coursed as in brickwork. The land side is filled in with any kind of soil to give a sound backing, and then, as the water gets into the material in the sacks, the cement hardens and a good and durable wall is formed, which increases in strength for some time. There is always a part of the material which exudes through the bags and cements the whole mass together; this, of course, assisting in the maintenance of a sound wall where there is no traffic. The top or coping layer of bags should be filled with a better quality of concrete so that it will stand against wear. A great point also is to keep the surface of the backing well level or slightly above the level of the top of the bags, as on this a great deal of reduction of breakage of the wall depends.—*Practical Engineer.*

NEW METHODS RELATING TO CONCRETE CONSTRUCTION.

The following interesting particulars deal with inventions devised by officers of the London County Council and relate to improved methods of concrete construction applicable to cottages, etc. We are enabled to publish these notes by the courtesy of Sir James Bird, Clerk to the London County Council.—Ed.

Invention No. 1.

This invention relates to ties for cavity walls and is particularly intended for application to cavity walls built of concrete.

The tie constructed in accordance with this invention is formed of concrete, cement, or similar moulded material adapted to resist both tensile and compressive forces, and is so shaped as to engage with the shells of the cavity-wall in such a manner as to resist both separation and approach of said shells.

The improved tie is preferably reinforced by metal reinforcement and is preferably so shaped as to deflect on to the outer wall moisture collecting on its upper surface, and to prevent moisture reaching the ties from the inner surface of the outer slab from running across the tie. The tie is also preferably provided with a substantially central drip edge on the lower surface.

The accompanying drawings illustrate the preferred form of the invention.

Fig 1. represents a sectional side elevation of a cavity wall showing one of the ties in position.

Fig. 3 shows a sectional elevation of one of the ties. The cavity wall shown is formed of outer slabs or blocks *O* and inner slabs or blocks *I* which are built up so as to provide a cavity *C* between them.

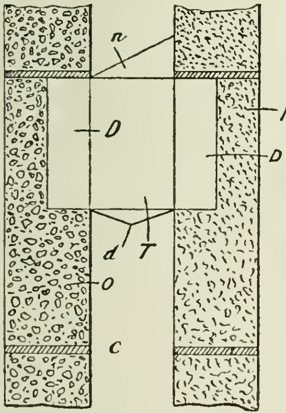


Fig. 1

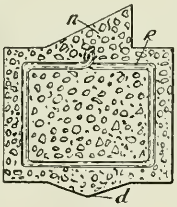


Fig. 3

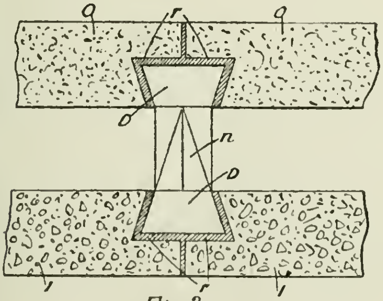


Fig. 2

The outer slabs in walls of this type are conveniently formed of hard concrete, while the inner slabs are formed of soft concrete.

It should be understood that the improved ties may be employed in cavity walls cast *in situ*; in this case the preformed ties are preferably cast into the concrete during the operation of pouring.

The ties *T* are formed of concrete reinforced with metal reinforcement *R* and are provided with dove-tailed ends *D* which engage similarly shaped recesses *r* formed in the slabs. These recesses are preferably provided in the meeting edges of the slabs and extend from the top to approximately half the depth thereof.

The upper surface of the tie is formed with a nose *n* of tetrahedral form; the purpose of this nose is to deflect towards the outer wall any water or other matter that may fall on it, and to prevent, so far as possible, any moisture which may run down the inner surface of the outer wall from creeping across the tie.

The under surface of the tie is formed with a drip edge *d* to cause moisture coming on to the tie to be directed to the centre of the cavity.

The invention may be summarised as follows:—

1. For use in cavity walls a preformed tie constructed of concrete, cement or similar moulded material so as

to be capable of resisting both tensile and compressive forces and so shaped as to engage with the shells of the cavity wall in such a manner as to resist both separation and approach of said shells.

2. The combination with a cavity wall built up of slabs, blocks or the like, provided on their inner surfaces with undercut recesses, of ties of concrete, cement or similar moulded material provided with ends adapted to co-act with the undercut recesses so as to prevent withdrawal of the ties from the slabs, blocks or the like.

3. The combination with a cavity formed of concrete shells cast *in situ* of ties of concrete cement or similar moulded material provided with ends shaped so as to resist the withdrawal of the ties from the concrete.

4. A wall tie as referred to in paragraph 1 provided on its upper surface with a nose or the like directed downwards towards the outer wall slab, and provided on its lower surface with a substantially central drip edge.

5. A wall tie of concrete, cement or similarly moulded material substantially as herein described and illustrated.

6. A cavity wall provided with outer shells composed of concrete tied together with dove-tailed ties of concrete, cement or similar moulded material substantially as herein described and shown.

INVENTION No. 2.

This invention relates to cavity walls employed in the construction of buildings and the like, and is particularly applicable to such walls when built of concrete or the like.

Hitherto, such party walls have been constructed mainly of two types, commonly known as the " closed cavity " and the other the " open cavity " respectively. The " closed cavity " wall has the advantage that it provides good heat-insulation, but has an attendant disadvantage in that timber running into the cavity is liable to rot because damp which finds its way into the cavity does not always dry out.

In the " open cavity " wall, gratings or the like are provided for ventilating the cavity and drying up any moisture that may occur, but such cavities do not provide good heat-insulation.

The object of the present invention is to provide a form of cavity wall in which the heat-insulating qualities are maintained, but in which means are also provided for ventilating floor timbers so as to avoid the disadvantage first mentioned.

The invention accordingly consists in a cavity wall constructed in the following manner. Open cavities are provided where floor joists or the like project into the wall, the adjoining principal wall areas above and below the floor being formed with closed cavities.

In the accompanying drawings, which illustrate the preferred embodiment of the invention, *Fig.* 1 represents a section through the upper portion of the cavity wall of a two-storeyed concrete building.

Fig. 2 represents a continuation of the section below the portion shown in *Fig.* 1.

Referring now to the drawings.

Above the foundations F is placed a closing block B^1 upon which the inner and outer shells I, O of the wall are built. The upper end of the cavity C^1 so formed is closed at the level of the sill S by tiles or plates T, and is similarly closed around the vertical edges of the window opening by the window frame W.

A block or a beam B^2 which also functions as a lintel, completely closes the cavity below the level of the floor joists J.

Above the block B^2 are placed inner and outer wall shells I^1, O^1, which are provided at intervals with convenient openings indicated in dotted lines, so that the cavity C^2 between them is ventilated, the air preferably having access also between the floor joists J.

This open cavity C^2 is closed by an upper block B^3; and the remainder of the wall in the upper floor is constructed with a close cavity in the manner described for the lower floor. The closing blocks or beam B^4 acts as a support for the timber of the roof R.

The invention may be summarised as follows :—

1. A cavity wall in which the joists of a floor projecting into said wall are received

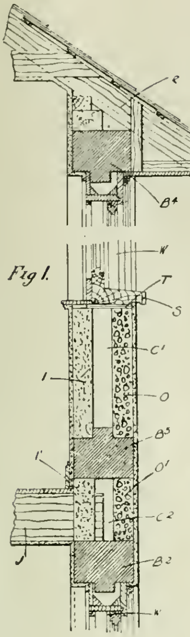


Fig 1.

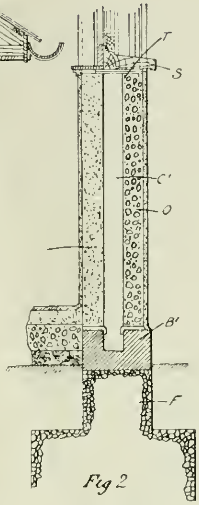
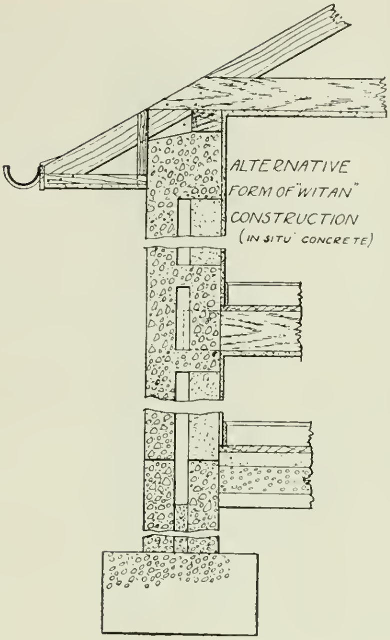


Fig 2



in one or more open cavities, the adjoining principal wall areas above and below said floor being formed with closed cavities.

2. A cavity wall in which a principal wall area between successive floors is formed with one or more closed cavities, the joists of the said floors being received in open cavities.

3. A cavity wall having closed cavities extending between the separate floors, ceilings, or the like and horizontally-extending open cavities at the levels of the said floors, ceilings or the like adapted to receive the joists thereof.

4. A cavity wall for concrete and like buildings substantially as herein described and shown.

Invention No. 3.

This invention relates to concrete walls and the like and has for its object to provide a method of constructing concrete walls in which the advantages of monolithic construction can be obtained without the usual attendant disadvantage involved in the cost of timber or like temporary formwork.

The method of building concrete walls in accordance with this invention consists in first making a cavity wall by aid of concrete blocks, provided on their inside surfaces with undercut grooves or other means of securing adhesion, and then pouring concrete into the cavity.

The poured concrete thus unites with the blocks which first act as temporary formwork and then become permanently cast into the complete wall.

The outer blocks of an external wall are preferably formed of hard concrete and the inner blocks of soft concrete.

The blocks are preferably assembled one course at a time, the concrete being then filled to a level approximately to one half the height of the course in question ; in this way the horizontal joints become staggered through the wall.

The outer surfaces are preferably formed with undercut grooves to facilitate keying of plaster or rendering.

In the accompanying drawings which illustrate the preferred method of carrying

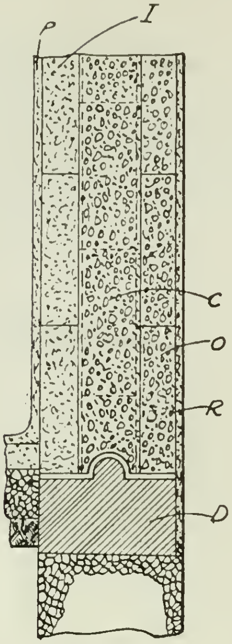


Fig. 1.

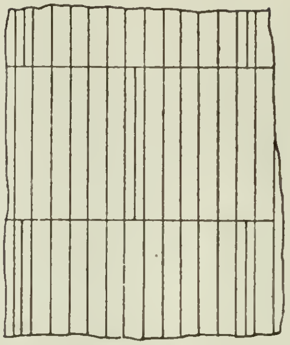


Fig. 2.

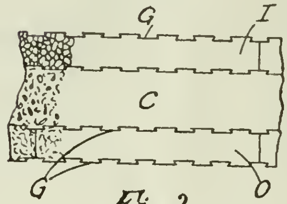


Fig. 3.

the invention into effect, *Fig.* 1 shows a section through the lower portion of a wall constructed in accordance with the invention.

Fig. 2 shows an elevation of a portion of the wall prior to plastering or rendering.

Fig. 3 shows a sectional plan of a portion of the wall.

Referring now to the drawing, inner and outer blocks or slabs *I, O* are first erected upon a damp course block *D.* These blocks are provided on their horizontal surfaces with co-acting ridges and grooves *G* to facilitate assembly and to assist in preventing ingress of damp through the joints.

A single course of these blocks *I, O* is preferably first erected and concrete *C* is then poured into the cavity to a height approximating to one half of the height of the blocks as indicated in dotted lines. Another course of blocks is then laid and concrete is poured into the cavity up to a level approximately half way up the second course of blocks and so on until the wall is completed, the topmost course being completely filled in with the poured concrete.

The blocks or slabs *I, O* are provided on their inner and outer surfaces with dovetailed grooves *G.* The grooves on the inner surfaces act as keys for the cast concrete and the grooves on the outer surfaces act as keys for rendering *R* and plaster *P* respectively.

The particular form of block which it is preferred to use for this purpose is that described in Invention No. 4.

The invention may be summarised as follows :—

1. A method of constructing concrete and like walls consisting in forming inner and outer shells of similar moulded blocks and slabs, provided on their inner surfaces with means for securing adhesion to concrete, and in casting concrete between the said inner and outer shells.

2. The employment as formwork for concrete or like walls of concrete or similar blocks or slabs provided on their inner surface with means for securing adhesion to concrete, the formwork being permanently cast into the wall.

3. In a method of constructing concrete and like walls referred to in paragraph

1, breaking the joint between successive blocks or slabs and successive layers of poured concrete substantially as herein described.

4. Concrete walls constructed in the manner substantially as herein described and illustrated.

The alternative form of the Witan System is devised to meet the following special difficulties :—

(1) The shortage of bricklayers. (2) The shortage of plasterers. (3) The coldness of rooms having open cavity walls. (4) The liability to dry rot in the floors of rooms having closed cavity walls. (5) The insanitary condition of walls having cavities in communication with the space between the floor boards of the upper storey and the ceiling of the ground storey.

The effect of roughcasting is obtained by inserting cocoa-nut fibre matting in the shuttering, and removing the matting after the concrete has hardened sufficiently.

Hitherto cavity walls have been constructed mainly of two types, commonly known as the " closed cavity " and the " open cavity " respectively. The " closed cavity " wall has the advantage that it provides good heat-insulation, but has an attendant disadvantage because the timber running into the cavity is liable to rot, and the dry rot is liable to spread throughout the whole area of the floor. In the " open cavity " wall gratings are provided for ventilating the cavity and drying up any moisture that may occur, but such cavities do not provide good heat-insulation.

The object of the Witan construction is to provide a form of cavity wall in which the heat-insulating qualities are maintained, but in which means are also provided for ventilating the floor timbers so as to avoid the liability to dry rot.

The Witan system consists in a cavity wall constructed in the following manner :—

Open cavities are provided where floor joists project into the walls, and the adjoining principal wall areas above and below the floor are formed with closed cavities.

The through concrete which closes the cavities will also tie the inner and outer leaves of the wall when the metal ties shall have rusted away.

INVENTION No. 4.

This invention relates to concrete and like moulded building slabs or blocks which are employed for building up walls, partitions and the like.

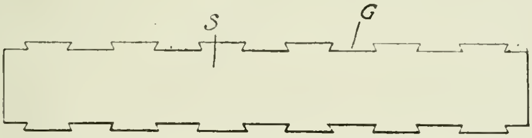


Fig. 1.

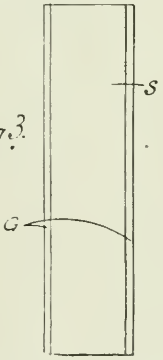


Fig. 3.

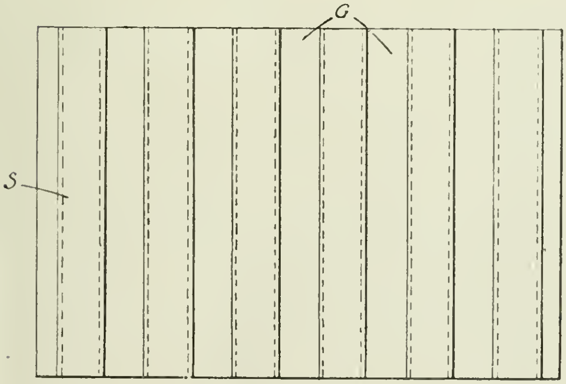


Fig. 2.

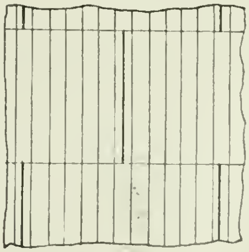


Fig. 4.

Slabs constructed in accordance with this invention are of the kind provided on each side with grooves for securing adhesion to plaster, concrete or the like, the characteristic feature being that the grooves on one side are so spaced that successive courses can be built up so as to break vertical joint and to form continuous vertical grooves in the wall.

In the accompanying drawings which illustrate the preferred form of the invention :—

Fig. 1 represents a plan of an improved slab. *Fig.* 2 represents an elevation thereof. *Fig.* 3 represents a side view thereof. *Fig.* 4 represents to smaller scale a wall or partition built up of the slabs.

Referring to these drawings, the slab S is formed on its two faces with undercut grooves G which are so spaced that when successive slabs are built up to break joint in the manner indicated in *Fig.* 4, there will be a continuous groove down the slab.

The slabs are preferably formed on one horizontal face with a central channel C, and on the other horizontal face with a co-acting central ridge R.

If, as is preferred, the grooves G on both sides of the block are exactly similar to each other, the slabs can be placed without the necessity of considering which side is to form the front and which is to form the back of the slab.

The invention may be summarised as follows :—

1. A building slab of concrete or like moulded material provided on both sides with grooves for securing adhesion to plaster, concrete or the like characterised in that the grooves on one side are so spaced that successive courses can be built up so as to break vertical joint and to form continuous vertical grooves in the wall.

2. A building slab referred to in paragraph 1 in which the grooves on both sides are exactly similar to each other so that the faces of the slabs are reversible.

3. A building slab substantially as herein described and shown.

INVENTION NO. 5.

This invention relates to wall-ties which are employed for maintaining at the requisite distance apart the shells of a cavity wall of a building or the like.

The invention relates more particularly to metal wall-ties in which a coating of enamel or the like is provided to protect the tie against corrosion by moisture and the like.

Such metal ties are usually made from a metal blank of rectangular section, the ends being fishtailed or similarly extended to give a grip in the mortar or concrete of the walls in which they are embedded. When such ties are coated with enamel or the like there is a tendency for the coating to crack at the sharp edges with the result that corrosion takes place.

In accordance with the present invention, the blanks from which the ties are made are formed without sharp edges so that the cracking tendency of the enamel or the like is minimised.

In the accompanying drawings which illustrate the preferred form of the invention :—

Fig. 1 represents an elevation of a wall-tie. *Fig.* 2 represents a plan of the same. *Fig.* 3 represents to enlarged scale the cross-section of the tie taken along the line XX, *Fig.* 2.

The tie is formed from a strip a of metal, the edges of which are rounded ; the degree of rounding may be varied, but it is preferred that the edges shall form semicircles.

A twist t is formed in the usual manner in the centre of the tie to assist in overcoming the tendency for moisture to creep from one side of the tie to the other.

The ends e are expanded or fish-tailed ; it is not essential that the edges of these ends be rounded because they become embedded in mortar or the like and so are protected from the action of moisture.

The invention may be summarised as follows :—

1. A wall-tie formed from a metal bar or strip, the cross-section of which possesses no sharp edges, for the purpose described.

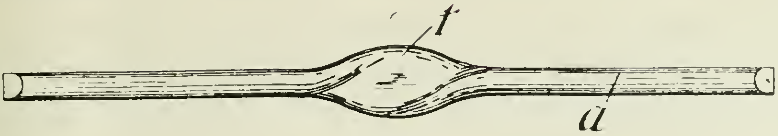


Fig. 1.

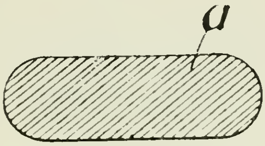


Fig. 3.

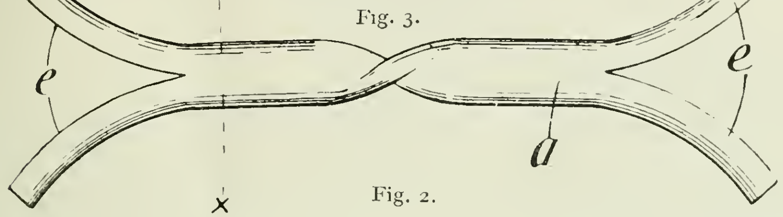


Fig. 2.

2. A wall-tie constructed from a metal strip or bar of which the cross-section is a rectangle with rounded edges substantially as and for the purpose herein described.

3. An enamelled metal wall-tie substantially as herein described and illustrated.

MEMORANDUM.

New Methods of Proportioning Concrete.—New methods of proportioning concrete mixtures, and the procedure found satisfactory for carrying them out in the field, formed the subject of a discussion at a recent meeting of the Toronto branch of the Engineering Institute of Canada, when Mr. R. B. Young, of the Hydro-Electric Power Commission of Ontario, described the experimental basis of the new theories, illustrating his remarks with slides.

Proportioning for Strength.—Mr. Young explained that the basis of the new theory is the idea of proportioning concrete to develop a certain desired minimum strength in a specified time. The Hydro-Electric Power Commission has adopted a specification based on this rather than on set proportions. Four classes of concrete have been established for the regular work of the Commission, as follows, each to develop the stipulated strength at an age of 28 days : Class A, 2,500 lb. per sq. in. ; Class B, 2,000 lb. per sq. in. ; Class C, 1,500 lb. per sq. in. ; Class D, 1,000 lb. per sq. in. These correspond roughly with the common proportions 1 : 1½ : 3, 1 : 2 : 4, 1 : 2½ : 5 and 1 : 3 : 6. This plan, it was explained, is much more logical than the specifying of a set mixture, because, for example, a 1 : 2 : 4 mix may under certain conditions give a strength as low as 500 lb. per sq. in., and under more favourable conditions a strength of 4,000 lb. per sq. in., depending upon the consistency, the materials employed and the methods of measuring and mixing.

Experience has shown that to the man in the field consistency is a more important feature than strength, because he does not know the strength required in the concrete and is not charged with responsibility for fixing the proportions.

Consistency.—The Hydro-Electric Power Commission has attempted to proportion concrete not only for a given strength but for a given consistency. On the groundwork laid by L. N. Edwards and Prof. Duff A. Abrams, a method has been developed that makes it possible to attain both a stated strength and stated consistency.

The principle outlined by Prof. Abrams is that for a certain ratio of quantity of water to quantity of cement, the same strength of mixture will be realised, regardless of the proportions, provided that the mixture is readily workable. This law is not absolute, however, as variations occur due to differences in materials and the relation of the fine to coarse aggregate.

REINFORCED CONCRETE HANGARS.

THE use of reinforced concrete hangars for dirigible balloons is extending in Italy. Two hangars built by the Société Porcheddu of Turin and described in the *Revue de Béton Armé* are 386 ft. long, 203 ft. wide and 123 ft. high. The foundations are designed to carry a load of only 28 lb. per sq. in. and are embedded to a depth of 13 to 14 ft.

The structure consists essentially of 14 pairs of columns at 22 ft. centres, 10 ft. by 2 ft. 6 in. wide and 63 ft. to the springer, tied together by arches 43 ft. in span. On each side of the hangar is a smaller building 170 ft. wide and 20 ft. high used for stores and offices. Access to the footways between the pillars, at the heights of 53 ft. and 109 ft. from the ground, is given by three stairways of reinforced concrete.

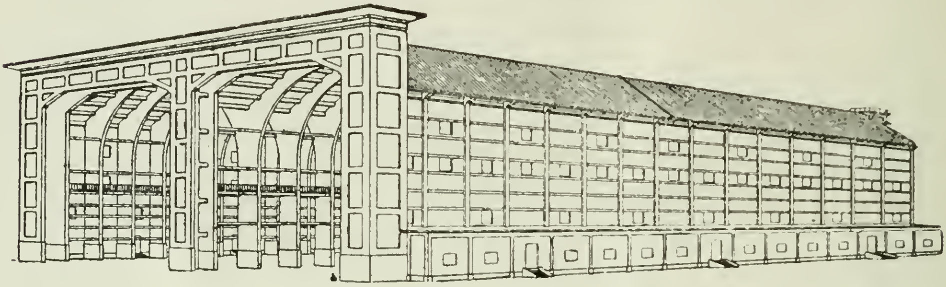


FIG. 1. PERSPECTIVE VIEW OF HANGAR.

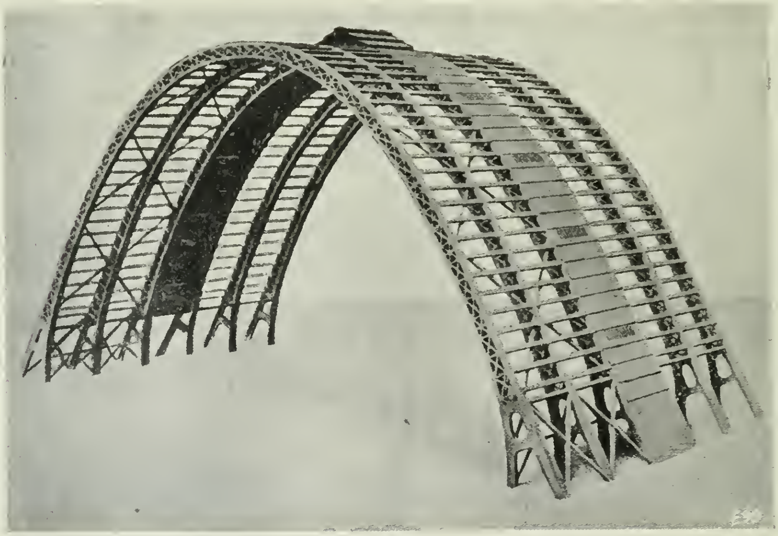


FIG. 2. VIEW OF PART OF THE MODEL OF THE LUCON HANGAR.

The imposing façade carries the double doors, each 93 ft. by 103 ft. and weighing 200 tons, and also two water tanks each of 2,000 cub. ft. capacity.

The central pilaster carries a load of 500 tons and has a bending moment of 19 ton-feet, the lateral columns a load of 400 tons and a bending moment of 70 ton-feet and the centre of the architrave a moment of 370 ton-feet.

More than 1000 workmen were employed at a time, and two pumps had to be kept constantly at work on account of the bad soil. The columns were moulded on the ground and raised into position as required.

The size of the structure is realised when it is remembered that each arch is equivalent to a very large bridge, but the latter would usually be built with two spans and that no less than 28 of these arches are required at a height of over sixty feet above ground level.

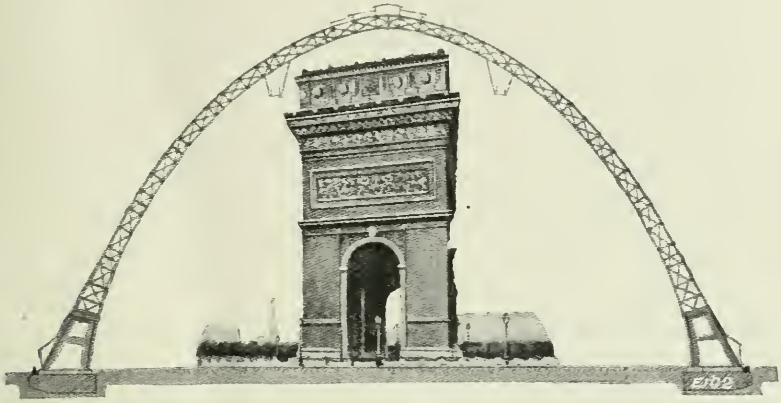


FIG. 3. VIEW SHOWING THE ARC DE TRIOMPHE IN PARIS STANDING BENEATH THE LUCON HANGAR.

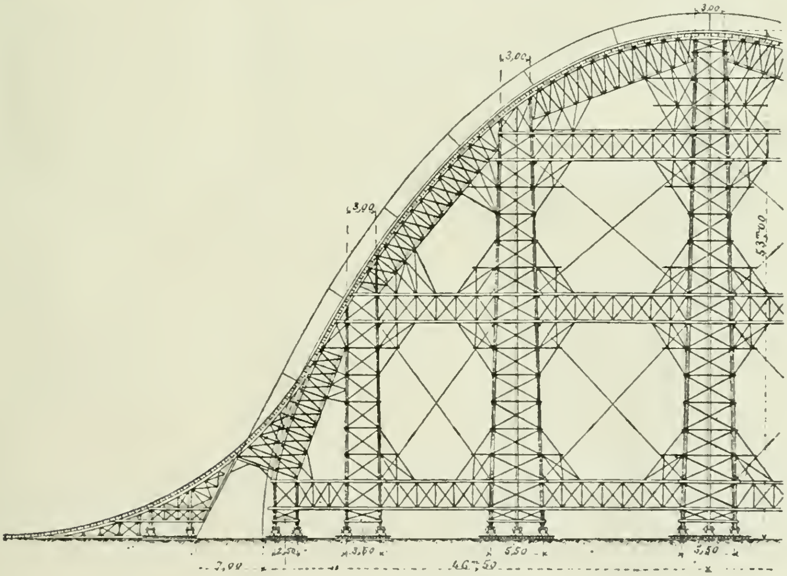


FIG. 4. VERTICAL HALF SECTION OF HANGAR SHOWING THE SCAFFOLDING.

A hangar recently built at Lucon Vendée, France, for two dirigible balloons and described in *Le Génie Civil* is so huge that the famous Arc de Triomphe in Paris could easily stand beneath it! The design, by M. A. Loissier, consists of an arch 176 ft. high internally, 186 ft. externally, 362 ft. wide and 733 ft. long. The reinforcement was prepared and the bulk of the concrete was precast, so as to secure a maximum speed of erection. The roof is of Minard tiles each 9 ft. by 6 ft. 8 in. by ½ in. and are made of highly reinforced concrete. The purlins are triangular in section and formed by three members united by trellis-like bars so as to be of minimum weight.

The main arch is of the catenary type, this being regarded as the most suitable for the pressures and loads concerned. Each arc is built of fourteen precast reinforced concrete segments, each 33 ft. in length. Longitudinal strength is given by means of trellis ties and by triangular diagonal braces to each three arcs. The arches were built by means of a series of five columns well tied together horizontally and mounted on rollers so that the whole series, with the centreing above, could be moved forward as the work advanced. Care was taken to lift two equal segments—one at each side of the scaffolding—simultaneously, a 100-ton winch being used for this purpose. The keystone segment was placed first and then the others in descending order, each being coupled to its neighbour in a simple manner. Special precautions were taken to prevent injury if a coupling broke. When all the segments had been joined each arc formed a flexible chain which automatically assumed the correct shape.

The tiles were fixed as rapidly as possible after the erection of each arc and by means of ladders from the centreing it was found possible to lay the tiles without walking much on the roof.

The structure is unusually elegant on account of its shape and thinness. As each arc is chain, its shape shows the load at any given point. The pressure due to snow is negligible as, on account of the shape of the arch, it can only remain near the top and therefore near the strongest part of the structure. Wind resistance is based on a pressure of 250 lb. per sq. yd. The design is such that variations of 30° C. do not affect its stability.

A DAM WALL OF REINFORCED CONCRETE FOR THE HASSLACHER WEIR.

THE possible advantages of reinforced concrete over mass concrete in large water-engineering enterprises are obvious, but unfortunately the saving due to a much smaller weight of materials is more than counterbalanced by the uncertainty as to the resistance of the reinforced concrete to internal stresses brought about by change in volume, variation in temperature, etc.

Dr. Rossin claims that the dam wall designed by him is quite free from secondary influences and that similar structures may be designed in accordance with definite static formulæ.

The dam-wall consists of an apron or separating wall and a series of single frames 23 ft. apart which support it, the cross section being roughly the shape of letter A. The cross-stiffening of these frames is of very small size on account of the small transverse forces which they have to resist. They are connected on the water side by a separating wall of horizontal arches.

Above the springer of this wall is an intermediate arch which protects the general load-carrying portion and gives the wall proper an harmonic extensibility which enables it to undergo longitudinal changes due to variations in temperature, etc., without damage. The connections between the main and auxiliary arches are quite water-tight and, in addition, the supporting frames are provided with a double frame with vertical joints which prevent the whole structure from twisting.

The main and auxiliary arches are of such a form and size that there are no tensional stresses exerted by the whole mass of water and there is a loaded bracket at the top of the retaining wall which creates a moment opposed to the water pressure and so prevents any undue strain on the structure.

The separating wall also has a horizontal course which stiffens it and the concrete frame and prevents the necessity of allowing for any movement in the arch.

The reinforced concrete frames which support the separating wall lie on two distinct foundations, each of which is under an almost central pressure for which

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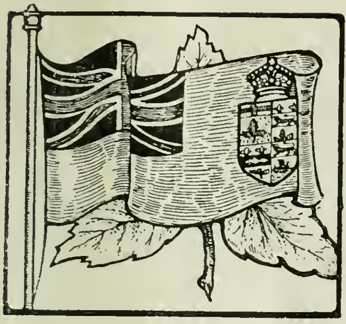


CIRCULAR CONCRETE RESERVOIRS AT LEAMINGTON, ONT.

An interesting example of the use of Concrete for reservoir construction is to be found at Leamington, Ont., where circular reservoirs were constructed to provide storage for one million imperial gallons of water. Our particulars and illustrations are taken from an article by Edward M. Proctor in the "Canadian Engineer," and we also wish to express our thanks to Mr. Edward M. Proctor for the loan of the original photographs for the purposes of reproduction.

WATER for the town of Leamington, Ont., is obtained from springs situated about 1¼ miles from the pump house. The supply is carried through a gravity pipe line. As this supply is barely large enough to meet the demands made upon the system during the hot weather, some measures had to be taken to improve the facilities. Well-pumping was tried, but did not prove very successful, and as the fire underwriters were demanding a storage reservoir for fire purposes, it was decided to construct a reservoir to provide a storage capacity of one million gallons.

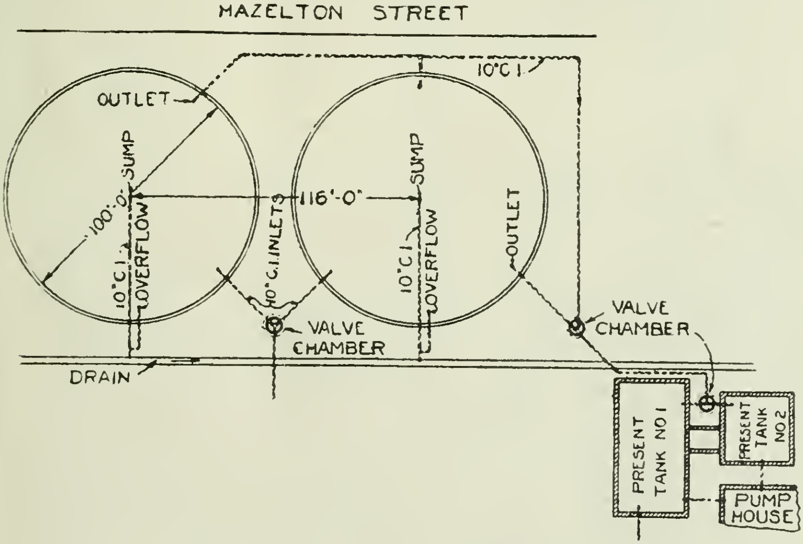


FIG. 1. GENERAL PLAN OF RESERVOIRS.

With a reservoir of this size it is possible to supply the town for several days without depending upon the supply from the wells. Also, in the event of a big fire, ample water is available.

After deciding upon the necessity and the size of the reservoir, the question arose as to its location. The gravity head fixed the height to which the water could be raised in any reservoir, and the elevation of the sewer determined the maximum depth; thus the allowable depth of water was fixed at 9 ft. It was first planned to build this reservoir rectangular in shape, with a cross dividing wall, but it was found eventually that by constructing two circular reservoirs, considerable saving would be effected in the cost of construction in spite of the fact that considerably more land would be required.

The general layout of these reservoirs is shown by the accompanying plan, *Fig.* 1. The tanks are 100 ft. in diameter and are located 116 ft. centre to centre.

The piping arrangement is rather novel, as it permits of either one of the basins being operated independently, or both being used in series. They are also so connected that they can be used independently of the old tanks. The sewer into which these tanks empty is a large concrete culvert section, which had been laid to take the flow of the small stream which formerly flowed along the line of the present drain.

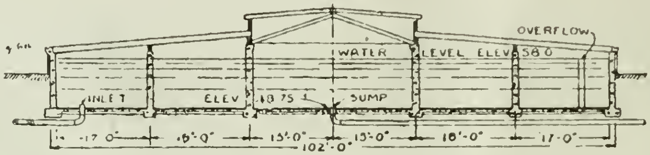


Fig. 2. Cross Section through Reservoir.

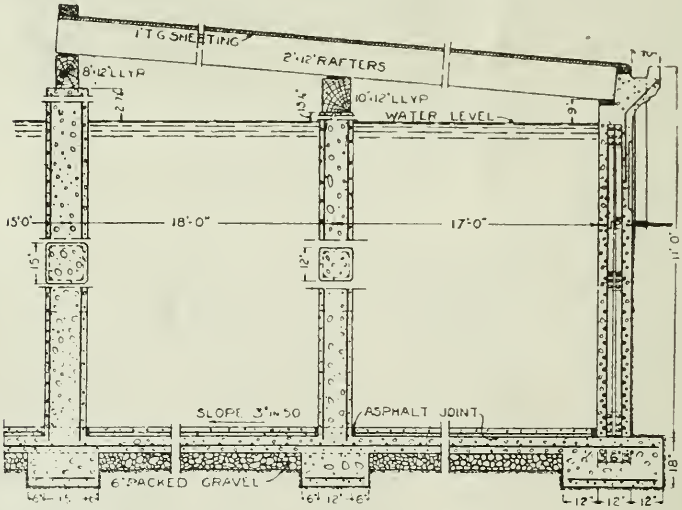


Fig. 3. Part Section through Reservoir.

Each tank consists of a floor, a circular wall, interior columns and a wooden roof. The columns are 12 by 12 in., concrete, resting on a footing 24 by 24 in., and each reinforced with four ½-in. steel rods. These columns are in two circles, the inner one 30 ft. in diameter and the outer one 18 ft. from the inner circle. The roof is of wood, treated with three coats of Barrett's "Carbosota Creosote" paint, and is carried by 2 by 12-in. rafters, bearing on pine timbers, which span from column to column. These spans are 15 to 17 ft. The centre portion of the roof above the louvre is carried by means of one wooden

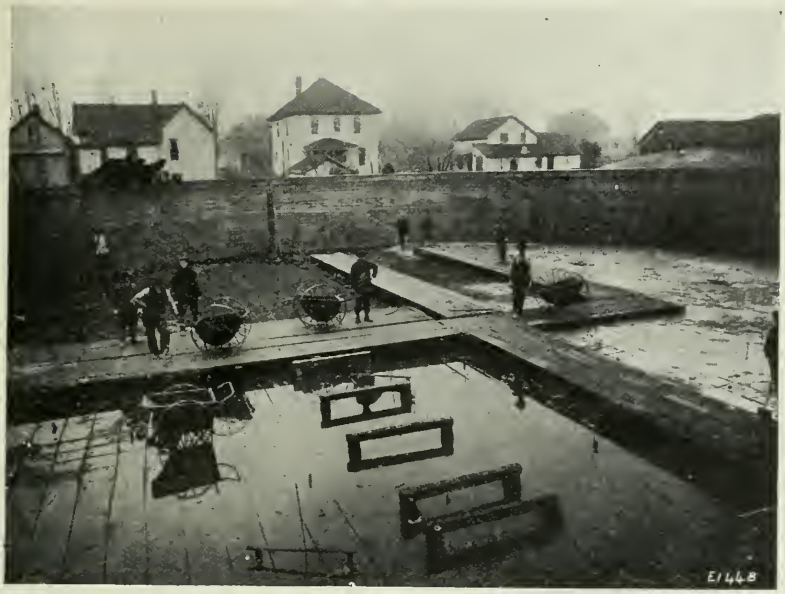


Fig. 4. Pouring Floor for Reservoir.

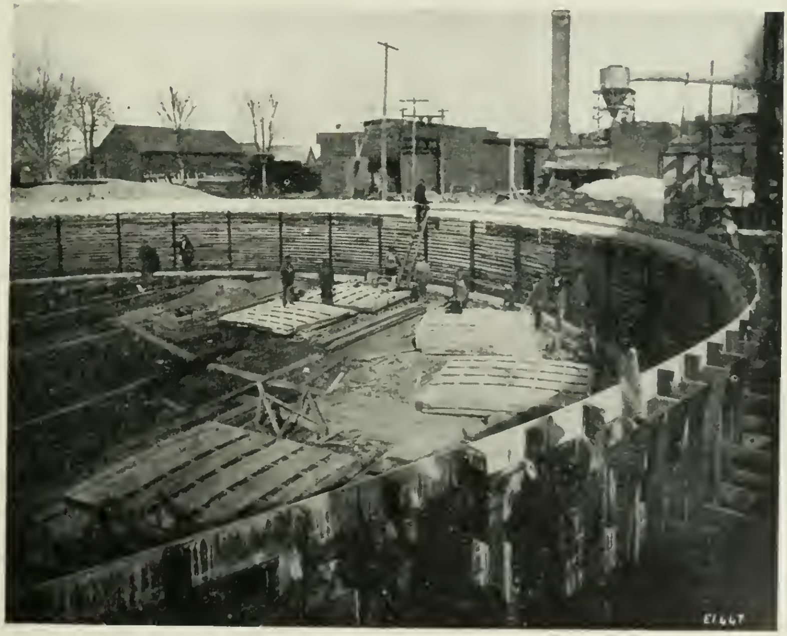


Fig. 5. Outside Forms and Reinforcing in Place. Inside Forms Ready for Erection.

truss supporting a centre block 12 in. in diameter, to which the joists connect. The louvre has a vertical opening of 18 in., and is covered with wire screen to keep out birds and insects. Over the entire roof is a four-ply tar and gravel cover. The roof has a slope of about 2 ft. 9 in. in 35 ft.

The floor of the reservoir is constructed in two courses, the lower course being 5½ in. of concrete, reinforced both ways with ½-in. diameter rods at 12-in. centres. On top of this course was mopped two-ply of 8-oz. burlap, swabbed on with hot asphalt, all joints being lapped. Above this burlap course was laid a 3-in. course of concrete, reinforced both ways with ¼-in. rods at 5-in. centres. Around all columns a 1-in. asphalt joint was constructed, and between this 3-in. top layer of concrete and the wall, a 2-in. asphalt joint was made. The lower course was laid directly upon the soil. The 6 in. of gravel were omitted, the reason being that the soil was pure sand, making an excellent foundation.

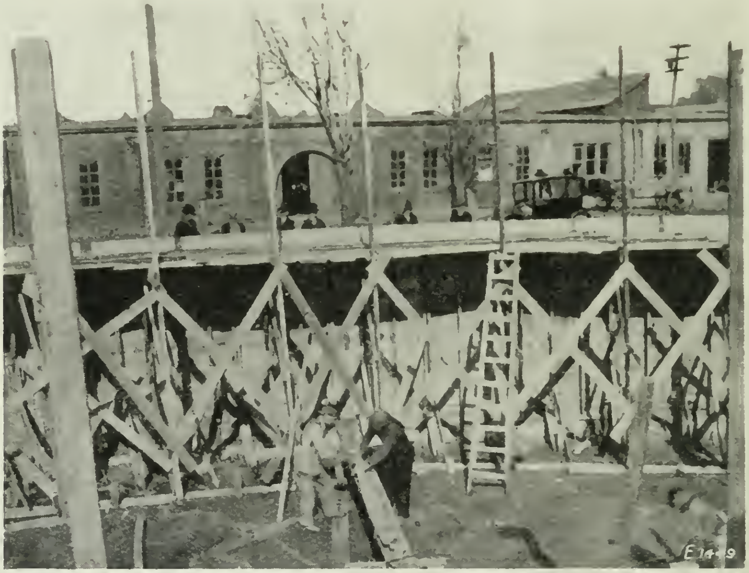


Fig. 6. View of Concrete Mixer, Hopper and Buggy.

As the ground water level was about 1 ft. above the level of the floor, and to avoid any possibility of hydrostatic thrust on the floor when the tanks are emptied, a system of drainage was installed. This consists of 4-in. field tile at 12-ft. centres, connecting into a main 5-in. tile under each tank. A 5-in. vitrified tile laid with open joints was laid around the complete circumference, and into this were connected the 4-in. cast-iron downspouts from the roof, which were eight in number for each basin.

Perhaps the most interesting part of the design is the circular wall. This wall is 12 in. thick and is reinforced circumferentially by means of the following rods: Twenty-two 1⅛-in. diameter, near the bottom, spaced from 4 to 6 in. apart; then six 1-in. rods at 6-in. spacing; and the top course, fourteen ¾-in. rods at from 6 to 9-in. centres. These rods are supported on structural steel struts,

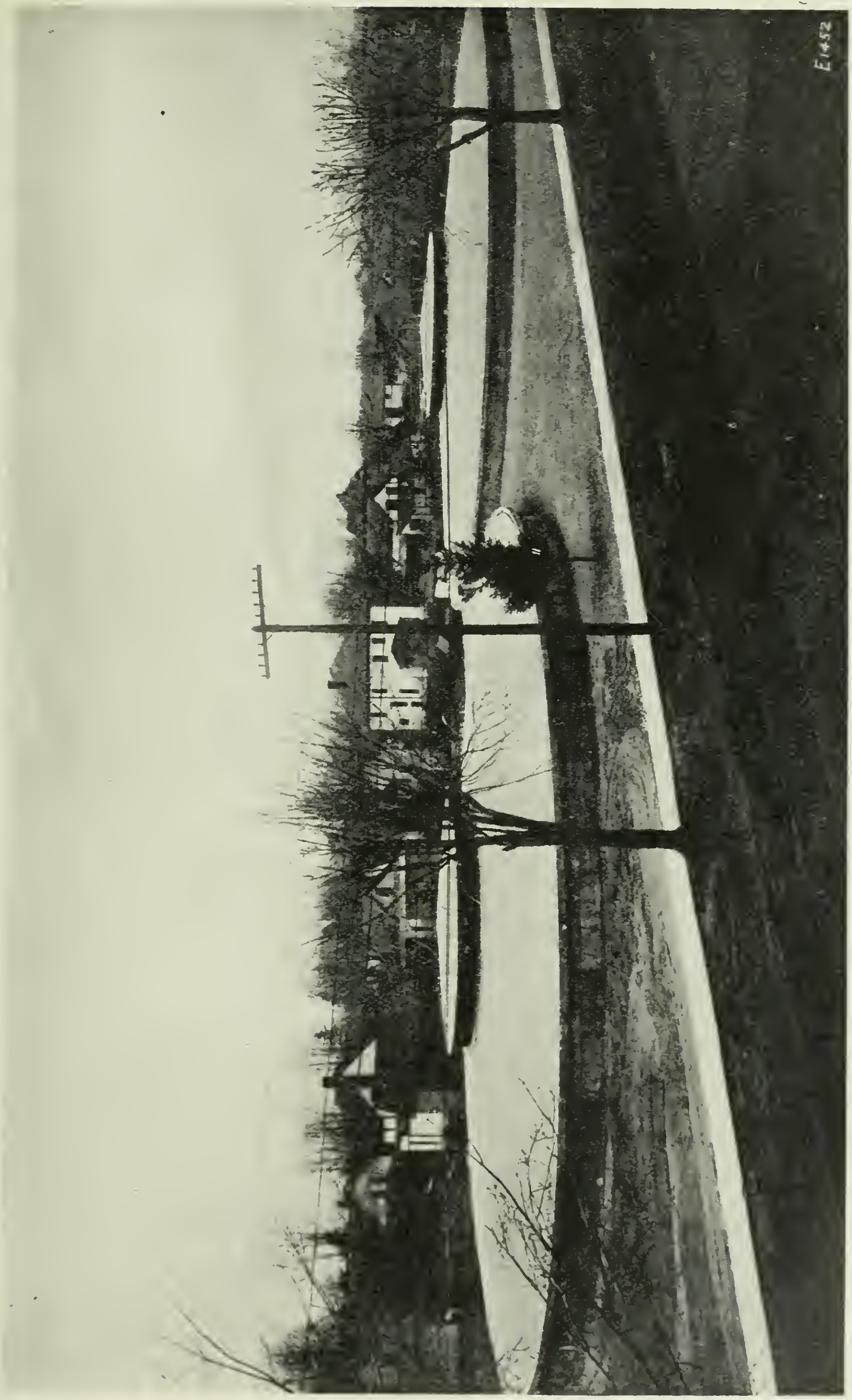


Fig. 7. View of Completed Reservoirs.

built of two angles, 2½ by 2 by ¼ in., connected by batten plates. These supports are placed at 8-ft. centres. This circular wall bears on a footing 3 ft. in width, which is also circular. The rods in the lower course of the floor projected from this footing. The wall is corbelled out at the top to provide for a gutter.

This wall has no physical connection with the footing. The method of construction was as follows: The footing was first poured and finished with a trowelled surface, upon which was applied a coating of asphalt. The outer forms were erected, and then the reinforcing was placed, after which the inner forms were placed, and when all was in readiness the concrete for the entire wall was poured continuously. The steel takes up the entire circumferential stresses, the concrete being simply a covering for the steel and means of containing the water. By leaving the wall free at its base, expansion and contraction stresses are eliminated. In order to provide assurance that the concrete will not crack when subject to full stress, a unit stress in the steel of 4,000 lb. per sq. in. was adopted. This unit stress is low enough that the resulting elongation in the steel will not crack the concrete.

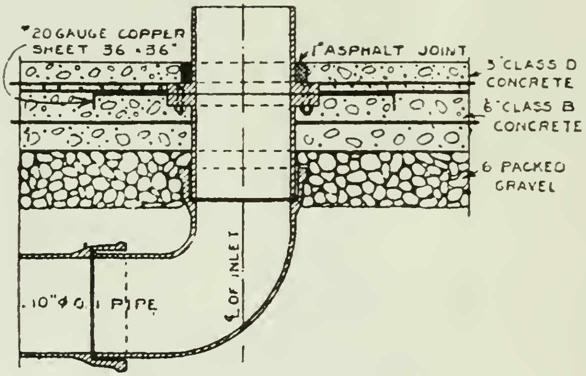


Fig. 8. Section through Floor showing Inlet Pipe.

In *Fig.* 8 is shown the method that was used to bring the various inlet and outlet pipes through the floor and to waterproof around same. These joints were found to be very satisfactory and have been absolutely water-tight.

Considerable study was given to this design to secure an appearance that would be as pleasing as possible. This was necessary because these tanks are in the centre of the residential section of the town.

The concrete used on this work was as follows: For the walls, 1 : 1½ : 3; the lower 6-in. course of the floor, 1 : 2 : 4; footings and columns, 1 : 2 : 4.

The specifications called for 10 per cent. of hydrated lime to be added to the concrete; that is, 10 per cent. by volume of the amount of cement used. With this mix a very dense and easily handled mix of concrete was obtained.

Reinforcing steel of a low grade was permitted on account of the low unit stress which was adopted.

The engineer in charge of this work was J. J. Newman, of Windsor, who is town engineer of Leamington. The plans and specifications were prepared by James, Loudon & Hertzberg, Ltd., consulting engineers, Toronto.

CONCRETE IN THEORY AND PRACTICE.

A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.

REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—Ed.

CHAPTER VII.

76. Having now considered the general principles of proportioning sand, ballast, and cement, we may now consider the materials separately, as the production of a good concrete depends on selecting the best from first to last—not only the best materials, but the best combinations, treatments, and so on—and this involves some knowledge of the various pitfalls which lie in wait for the inexperienced.

77. *Cement.*—The strength of the concrete depends absolutely on the cement, and in reinforced concrete it is essential to use the best obtainable.

Cement is a mixture of chalk and clay in the correct proportions, intimately mixed, burnt, and ground.

In some places, notably Belgium, strata are found containing chalk and clay in roughly the right proportions, and these when burnt give a so-called *natural Portland cement*, but as the proportions vary a good deal the result is very uncertain, owing sometimes to too much chalk and sometimes to too much clay in the cement.

Natural cement should never be used for reinforced concrete, but only *artificial Portland cement* of the best quality.

For our present purpose we need not discuss the method of manufacture, but we must consider a few of the properties which are important to the user.

When cement is mixed with water, sufficient to form a thick porridge, it gradually begins to *set* or become solid. Now the time taken in setting is very important, because after setting has begun, any disturbance weakens and may destroy the finished concrete. We distinguish two setting times, the *initial* and the *final*.

It must be understood that the setting is really a gradual process having no well-marked beginning or end, and undoubtedly chemical changes occur before the initial and after the final set, so that these must be regarded only as arbitrary but convenient comparisons of the behaviour of different cements, and not as denoting any absolute beginning or ending.

The British Standard Specification gives the initial set as the time when a needle 1 millimetre square in section, loaded with a definite weight, gently lowered on to the cement just fails to completely penetrate it, and the final when it just fails to make an indentation on the top surface.

Cements are divided into quick, medium and *slow setting*, and for the purposes of reinforced concrete only slow setting should be used, as the others do not in practice allow the materials to be properly mixed, wheeled, deposited, and worked round the steel before setting may begin.

In testing for setting time, it is important to use the correct quantity of *water* and to have the *temperature* about 60° F., as the time depends greatly on these two factors. The same applies in practice with the concrete. A cement with a final set of one hour at 60° may take many hours to set at 40° F. and may set in ten minutes at 100° F.

Remember that when the final set has taken place, the strength is practically nil and *hardening* begins.

This is also a gradual process having no real beginning or end, but roughly the strength increases uniformly with age for the first seven days and afterwards at a gradually reduced rate, and roughly will vary as follows :

7 days	1000	lb.	sq.	inch ultimate compression
28 days	1500	,,	,,	,,
4 months	2250	,,	,,	,,
12 months	2500	,,	,,	,,

After one year, the strength varies little, but seems to rise and fall in a peculiar manner which we need not concern ourselves with here.

Consequently, if centering or strutting is removed in less than 28 days, remember that the concrete has not reached its full strength, and should not receive its full load unless the design specially provided for this.

Next after setting, the *strength of the cement* is important.

The British Standard Specification provides for specimens 1 in. square to be tested in tension, some neat cement, and some 3 to 1 standard sand to cement, both at 7 days and in 28 days.

Unfortunately the standard required is much too low, as manufacturers are able to produce a far better cement than is needed to pass British Standard, and this greater strength results in a stronger concrete.

There is no difficulty to-day in getting 300 lb. per square inch in 7 days with a 3 to 1 sand specimen, and 650 lb. per square inch in 7 days with neat cement, although British Standard asks for much less.

Fineness of grinding is very important, since a cement obviously has far better covering power when ground small. But the user need not worry about this if he sees that his cement gives good strength tests, since it is necessary to get fine grinding to achieve these high tests referred to. It should be remembered that fine grinding means considerable additional manufacturing cost, but is well worth it.

Aeration of cement, that is, exposing it to the air some time prior to use, is important because it often contains free lime which may spoil the concrete by causing heat, cracking, etc., whereas any such free lime will be slaked if exposed to the air or carbonated, and so rendered innocuous. As a rule, cement is supplied ready aerated, but occasionally is despatched hot, and should then be spread in layers 12 in. thick and turned a few times for a week before use.

Storage.—When small quantities only are required, they may be kept in a dry warm place in sacks for a few weeks.

If kept long in sacks, the moisture in the air has access to a very large surface, and the cement begins to set all round the sacks, and suffers in consequence.

Hence on large jobs, it is better to store in bulk, emptying the cement out of the sacks into a cement store, and so exposing a lesser surface. This store should have a dry floor kept a few feet above the ground, and walls and roof so made as to keep out rain and moist air and free from condensation. Timber and felt is good while corrugated iron is bad.

When cement has been stored long it is well to test the setting time again, since occasionally the effect of thorough aeration is to alter this in a very remarkable manner, sometimes in the direction of making it very rapid indeed, and sometimes making it very slow, the determining factor being apparently whether the air contains carbonic acid or moisture to a greater extent.

78. *Sand.*—Sand for good concrete must be *clean* and *large*. Roughly the grains should be about $\frac{1}{16}$ in. in diameter.

It is clear that a very fine sand contains much more surface in a given volume, and therefore needs more cement to cement the particles together—or conversely, a given proportion cement gives stronger mortar with a large sand.

The importance of cleanliness is very great. Frequently the sand as found in the pit has a film of loam or clay round each particle. This prevents the cement adhering, and a very weak concrete may result.

The author has made tests showing that a large clean sand mixed 3 to 1 gave about 2,000 in one month, while a clean but fine sand, or a large but loamy sand gave only 500 or one quarter. In these experiments the fine sand was a blown sand as the seaside, and the loamy one was a red sand from Croydon gravel.

In both cases the use of such a sand would have spelt disaster.

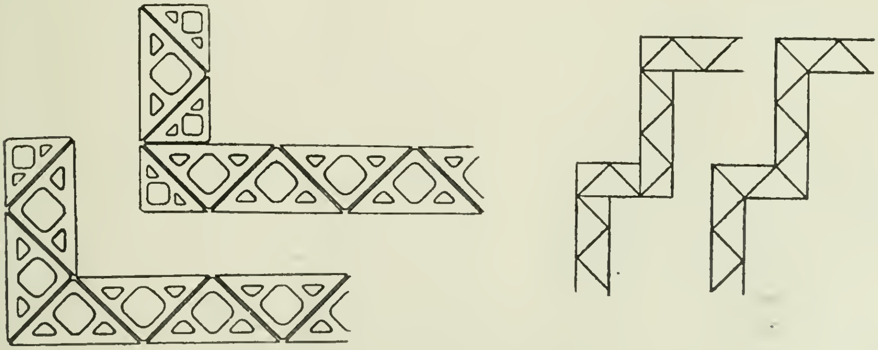
It used to be specified that the sand should be *sharp*. Later tests, however, show that the shape of the particles does not matter, and round ones are as good as sharp ones, provided they are large and clean.

THE BUILDING TRADES EXHIBITION, 1921, OLYMPIA.

THE second post-war Building Trades Exhibition, held at Olympia last month, provided much of interest to all concerned with building. Following as it did within twelve months of the previous show, it was not to be expected that as many new machines and new methods of construction would be on view as last year, when the Exhibition embodied much of the results of the inventions made and experience gained during the phenomenal years of the war. However, methods and plant that were new, the improvements on systems and machines that are already well-known, and the endeavour demonstrated on many of the stands to obtain a better finish and texture to concrete, were of considerable interest, and give hope for both a reduction in cost and an improvement in appearance of concrete building in the near future. The adaptability of concrete to new purposes was noticeable on many of the stands, such as concrete fireplaces and mantels, window sashes, and cisterns and every description of rain-water goods in asbestos cement.

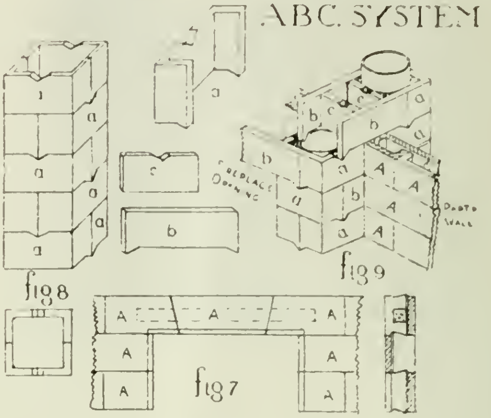
BUILDING CONSTRUCTION.

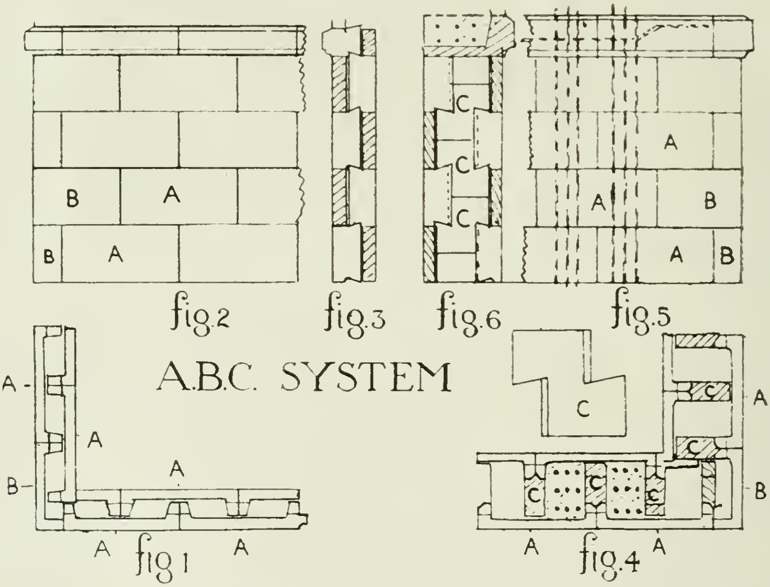
An ingenious new system of concrete construction was exhibited by the *Triangular Concrete Construction Co.* (Imber Court, Thames Ditton), in which a number of triangular blocks are used of different dimensions, but wherein each size smaller than the



"TRIANGULAR" BLOCK CONSTRUCTION.

next largest is in area exactly one-half of the larger. It is obvious that by the use of a number of right-angle isosceles triangles practically any formation can be obtained, and that this is so, and that bay windows, buttresses, return ends, columns, etc., can be formed without cutting was demonstrated by the sections exhibited. Where desired, the blocks may be made with ballast concrete on the face which will be exposed to the weather and of porous aggregate on the other two sides. To economize in material, and to form an air-space in the wall, the blocks are made hollow. To form a 9-in. wall blocks are used measuring $17\frac{1}{2}$ in. along the outer face and $8\frac{3}{4}$ in. on the other faces laid to bond together, return ends and corners being formed with blocks of exactly half those dimensions. The blocks are laid to break joint in each course, and vertical air-spaces are thus obtained throughout the entire height of the wall. The blocks are made in six sizes, from $4\frac{1}{2}$ in. along the face to 2 ft., and walls of any thickness can be built with them. The Company is in a position to supply quantities of these blocks, or machinery for their manufacture.

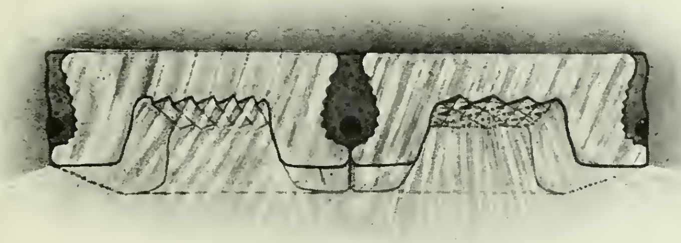




"Thewlis" System of Concrete Construction (*see p.* 331).

The well-known expanded metal reinforcements manufactured by the *Self-Sentering Expanded Metal Works, Ltd.* (110, Cannon Street, E.C.4) were displayed to advantage by sections of floors, ceilings, and walls in which the material was incorporated. These reinforcements are specially designed to dispense with the use of forms in the construction of light concrete structures, and are now being extensively used for that purpose. "Self-Sentering" is ribbed expanded metal, especially designed for floor and ceiling construction, and which will retain wet concrete. "Trussit," designed for wall construction, is an expanded metal sheet which when covered with two inches of cement plaster forms an excellent wall for use in housing schemes. For suspended ceilings or partitions, "Herringbone" metal lathing was shown. This material is rigid and strong, and only requires studding at 16 in. to 20 in. centres to keep it in place. Floors, ceilings and walls built with these materials are sound-proof and fire-resisting, and as the expanded metal remains as an integral part of the structure, all the strength of reinforced concrete is obtained without the use of shuttering. They have been approved by the Ministry of Health for State-aided housing schemes, and are being used on such schemes on a large scale.

A new system of concrete block construction, by which the blocks are interlocked by a method of dovetailing, was shown by *Mr. J. Thewlis* (2, Manor Terrace, Headingley, Leeds), an architect. In our illustrations (p. 330), *Fig.* 1 shows the setting out of an angle to a 9-in. wall; *Fig.* 2 is the elevation of *Fig.* 1, showing 24-in. blocks (A), which are the standard size, and smaller blocks (B) used to break joint; *Fig.* 3 is a section through *Figs.* 1 and 2, showing the dovetail lock, and the clear air-space throughout the wall; *Fig.* 4 shows the application of the same block in the construction of an 18-in. wall, the block (C) serving to hold the outer and inner walls apart; if desired, the cavities can be filled with concrete and reinforced; *Fig.* 5 shows an elevation of *Fig.* 4, with the string course reinforced as a solid beam; *Fig.* 6 is a section through *Figs.* 4 and 5, showing the interlocking arrangement. The application of the system to details of construction is shown in *Figs.* 7, 8 and 9. *Fig.* 7 illustrates a window or door head formed of blocks with raking joints; *Fig.* 8 shows a square shaft or column; the locking device is employed on opposite sides in alternate courses, thus locking the whole against lateral stresses from any direction; *Fig.* 9 is a chimney flue designed to serve for two adjoining houses. The system has the merit of simplicity, and the dovetail joints ensure a rigid construction.



"King" Pavement Lights.

Some interesting specialities were shown on the stand of *Messrs. J. A. King & Co.* (181, Queen Victoria Street, E.C.), who, in addition to solid and hollow concrete blocks and slabs, exhibited their reinforced concrete glazing bar as applied to pavement, floor, roof and stallboard lights. The glazing bars are strongly reinforced, and possess many advantages over the ordinary type; for example, they improve in strength with age, they cannot rust, and the expense of periodical painting is eliminated. They are quite pleasing in appearance, and when used for pavement lights are much more in harmony with the surrounding pavement than metal glazing bars. A further advantage is that in wet weather they will not tend to become slippery.

The Moler Fireproof Brick and Partition Co., Ltd. (Vickers House, Broadway, S.W.) demonstrated the various constructional uses of their special brick by sections of walling, floors, partitions, etc., and the warm reddish-brown colour had a very pleasing effect. In addition to their good appearance, the bricks are remarkably light, while they are at the same time of exceptional strength and fireproof. The bricks are made both solid and hollow to standard and other sizes and of any pattern for special purposes, and they are also made with various surface finishes. The material from which they are made, "Moler," is porous, and when coated with cement or other waterproofing material forms a light, strong, waterproof construction, the absorbent nature of the interior preventing trouble from condensation. "Moler" is a deep-sea deposit of diatome-silex mixed with alumina of which the Company owns large deposits of fine quality at the Island of Mors, Denmark. It has high insulating qualities, and should be in considerable demand where light yet strong structures are required.

The possibilities of asbestos cement in its various forms, both as a sound material for the construction of light buildings and as a material which provides considerable scope for artistic treatment, was admirably demonstrated on the stand of the *British Fibrocement Works, Ltd.* (22, Laurence Pountney Lane, E.C.), the makers of "Fibrent" asbestos-cement sheeting, tiles, etc. Two gables were shown to illustrate the uses of curved corrugated sheets and scolloped slates. Half-inch sheets fixed direct to the joists formed a very substantial floor, and several finishing methods were demonstrated in the treatment of the interior.

The British Roofing Co. (150, Southampton Row, W.C.1), demonstrated the uses of their "Alligator" brand asbestos cement sheeting and slates in various colours, and "Everite" and "Asbestilite" products were exhibited by the *British Everite & Asbestilite Works, Ltd.* (29, Peter Street, Manchester). The latter firm exhibited a selection of rainwater goods, gutters, down-pipes, etc., made of this plastic material, and its possibilities were further shown by an asbestos cement water cistern, in light grey, which we understand has been approved by the Ministry of Health for use in State-aided housing schemes. The cistern is of pleasing colour and shape, and costs less than the usual iron cistern. The stand of the *British Uralite Co.* (1908), *Ltd.* (8, Old Jewry, E.C.2) took the form of a garage carried out in "Asbestone" asbestos cement sheeting and tiles.

Messrs. G. R. Speaker & Co. (Eternit House, Stevenage Road, London, S.W.6) exhibited an example of the application of their "Eternit" sheets to the construction of one-story buildings on their patent "Trellit" principle. In a few words this consists of a light steel framework covered with "Eternit" sheets. The framework is assembled at the Company's works in sectional units four feet wide which are fastened together in such a way that, for purposes of transport, they may be folded up into quite a small space. The framework is made of channel steel, the members being 5 in. in depth. To the steel framework wooden strips are attached and to these the "Eternit" sheets are fixed, thus forming a wall containing a 5 in. cavity.

The Climbing Steel Shuttering Co. (515, Queen's Row, Sheffield) exhibited their system of shuttering for forming monolithic concrete walls. In this system the galvanised steel plates which form the shuttering are erected above the dampcourse and filled to form the first course of the wall. The plates are held apart top and bottom by wires, and when the concrete in the lower course has set the bottom wires are cut and the plates lifted outwards and upwards to form the shuttering for the next course, the original top wires acting as hinges. This operation is repeated until the desired height is reached. As each face of the plate becomes the inside face alternately in its progress up the wall, both sides are made smooth in order to obtain a satisfactory finish.

Several other systems of concrete building which are well known to our readers were also demonstrated.

Messrs. Concrete Dwellings (Parent Company), Ltd. (1, Carteret Street, S.W.1) exhibited their method whereby walls are laid *in situ* by means of a patent mould. *Messrs. J. Wright & Co.* (South Western Works, New Malden, Surrey) demonstrated their "Utility" concrete block construction, in which ballast blocks are used for the exterior wall and breeze blocks for the interior, the whole being bonded together by tongues and grooves. The "Fidler" ("Composite") method of concrete construction was demonstrated by the *Composite Concrete Construction Co.* (51, Pall Mall, S.W.1). The cavity walls are formed of large pre-cast slabs 2½ in. thick, 3 in. apart, laid to break joint and held in position by wall-ties. *Messrs. Panels, Ltd.* (14, Red Lion Square, W.C. 1) showed two systems, viz., the "P. & P." and the "B. K." The "P. & P." system consists of concrete piers spaced at about 3 ft. centres, filled in with concrete panels 2 in. thick, spaced 3 in. apart to form a 7 in. cavity wall. The "B. K." system is a form of interlocking concrete block construction.

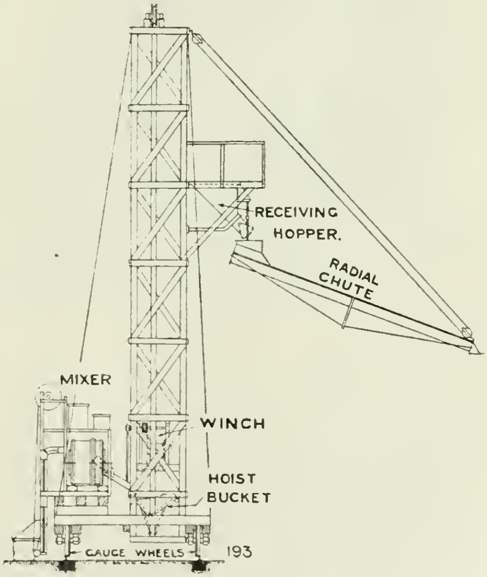
A patent concrete eaves was shown by the *Economic Eaves Co.* (9, Southampton Street, Bloomsbury, W.C.1). Now that gutters and such materials are so difficult to obtain there should be a considerable scope for concrete eaves, which effect a considerable saving in rain-water goods, timber, etc.

The well-known "Ruberoid" roofing and dampcourse materials were demonstrated by the *Ruberoid Co., Ltd.* (81-3, Knightrider Street, E.C.4) by a series of interesting models showing the application of these materials to various types of roofs, gutters, flashings, dampcourses, etc. "Ruberoid" is a self-finished bituminous material which has been in use for twenty-nine years. It is now supplied in two colours in addition to the familiar black, namely, red and green, and the models showed the attractive results that may be obtained by the use of these coloured coverings. A durable and easily laid acid-proof and damp-proof floor covering was shown, particularly suitable for covering concrete floors; it is manufactured in two colours—red and grey.

MACHINERY.

The stands containing machinery were perhaps the most interesting in the Exhibition, ranging from small hand block-making machines that can be used with economy for the smallest job, or for repair work, to large concrete mixing and placing plant that would replace a small army of workmen on a large job.

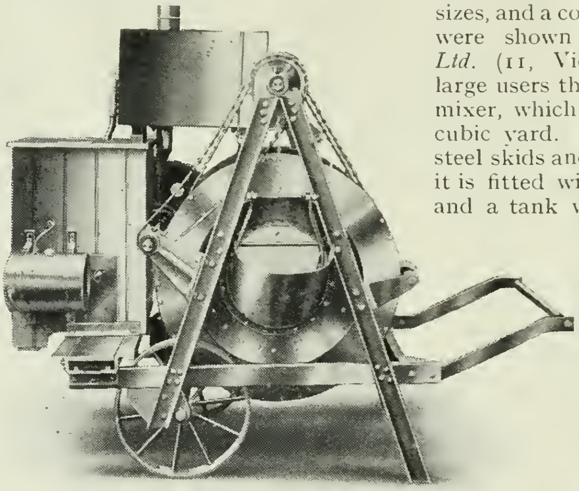
On their two stands, the *Ransome Machinery Co.* (1920), *Ltd.* (14–16, Grosvenor Gardens, S.W.1) showed a comprehensive exhibit of contractors' plant. The well-known "Ransome" pile driving equipment, viz., steel sheet piling, steam friction piling winch, and pile helmet for concrete piles, was shown, and the "Ransome" hand tip-cart, constructed entirely of steel, and made in sections which can be readily taken apart and fitted together again. Self-contained petrol-driven concrete mixers and tar-macadam mixers were also shown. The most interesting exhibit on this stand was a large concrete mixing and distributing plant, one of the largest such combinations we have seen in this country. The mixer is of the standard "Ransome" revolving-drum type with a batch capacity of 7¼ cubic feet, which discharges direct into a hopper in a steel framework tower. The tower can be of any desired height, and the hopper is lifted to the top by a power-operated wire rope, where it is automatically tipped, and the contents discharged into another hopper from whence it flows by gravity into the distributing chute. The outfit, which is fitted for belt drive, is compactly built and contains many ingenious contrivances that will commend themselves to those interested. The combination is, we believe, equal to anything of its kind that has been used in America, and the adoption of such plant in this country would rapidly repay its first cost on large works.



Ransome Portable Combined Mixing, Hoisting and Placing Plant.

Messrs. Millars' Timber & Trading Co., Ltd. (Pinner's Hall, E.C.2) exhibited a fine selection of builders' plant and labour-saving machinery, including an all-steel derrick, suitable for hand and power operation, a special feature of which is the speed with which it can be erected and dismantled ; portable and stationary self-contained petrol-driven hoists ; petrol-driven compressors, diaphragm pumps ; electrically-driven wood-working machinery ; stone crushers ; and the well-known " Jaeger " mixers. Messrs. Millars' supply practically every description of plant used in building construction suitable for small or large users, and large numbers of them are in use and giving satisfaction in all parts of the world.

Messrs. Hill & Co. (*Engineers*), *Ltd.* (York) also had a very fine display of labour-saving devices. A working model was shown of the " Sauerman " drag-line excavator, by the use of which it is claimed one man can excavate sand or gravel at the rate of 1,000 cubic yards per day and dump it into screens, or where required. The excavator is of the shovel type, and is drawn and returned from the point of excavation to the top of the hoisting tower by means of a double-drum hoist. On reaching the point where the material is to be dumped, the shovel is automatically tipped to release the contents. Several portable cranes of novel design were shown for hand and power operation.



The " Victoria H.M." Concrete Mixer.

A selection of concrete mixers of various sizes, and a couple of block-making machines, were shown by *Messrs. Stothert & Pitt, Ltd.* (11, Victoria Street, S.W.1). For large users there was the " No. 5 Victoria " mixer, which has a batch capacity of one cubic yard. This machine is mounted on steel skids and is designed for a belt drive ; it is fitted with a batch discharging hopper and a tank which automatically regulates the amount of water for each batch — a valuable feature when the necessity for accurately gauging the water content of concrete is borne in mind. A self-contained mixer with a smaller output per batch (6 cubic ft.) was shown in the " No. 0 " machine, which is mounted on a road wheel truck with a 6 h.p. petrol engine on an extension of the frame. This machine is also fitted with an automatic water tank, and has a side loader. A machine specially suitable for housing schemes and for small users is the " Victoria H.M." This is also a self-contained unit mounted on wheels, and can readily be moved about by two men. It is fitted with a 2½ h.p. paraffin or petrol engine, or, if desired, it can be used as a hand machine by disconnecting the engine and fitting a pair of handles. This firm also exhibited the " Dri-crete " block-making machine, the special feature of which is that in the process of manufacturing the block a thin layer of waterproofing material is applied to the face.

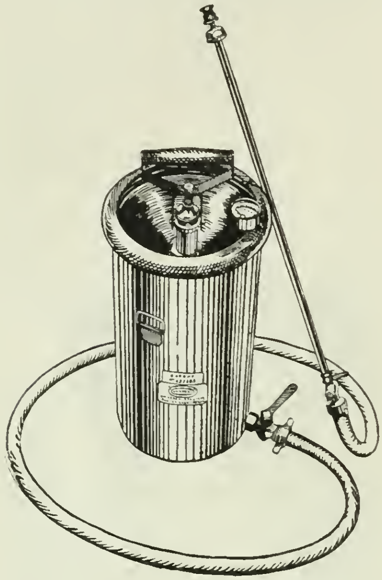
The British Steel Piling Co. (Dock House, Billiter Street, E.C.) exhibited a good range of contractors' plant, especially in relation to pile driving. " Universal Joist " and " Simplex " steel sheet piling, which possess the important qualities of being easily driven and withdrawn, were exhibited in sections. An interesting model was shown of a " B.S.P." standard pile-driving frame with a McKiernan-Terry hammer at work driving and withdrawing piles in a bed of sand, showing the speed at which this apparatus works, and some of the smaller sizes of this type of hammer were shown separately. These apparatus may all be hired from the B.S.P. Company, if desired. Two sizes of concrete mixers were shown on this stand, the " Zenith " and the " Zenith Pup." The former has a capacity of one-quarter yard of material, and is fitted with a fixed hopper ; it is arranged for a belt drive, and has an output of from 75 to 300 cubic yards per 10-hour day, according to size. The " Zenith Pup " has a smaller output (about 38 cubic yards per 10-hour day), and is specially designed to meet the requirements of builders and contractors on small jobs ; it is an entirely independent unit, driven by a petrol engine mounted with the mixer as one unit.

The efficiency and durability of the concrete machinery of *Messrs. Winget, Ltd.* (Grosvenor Gardens, S.W.1) are well known to those who have used them, and any new production by this firm will be examined with interest. In addition to their hand and power block-making machines, mixers, elevators, etc., they showed at the Exhibition for the first time a new hand block-making machine—the " Westminster." This machine should be particularly useful on small jobs, and only requires one man for its operation. It can be adapted for the manufacture of blocks, slabs, or bricks, as follows : Single blocks, 18 in. by 9 in. by 4½ in. ; single slabs, 18 in. by 9 in. by 2, 2½, or 3 in. thick ; half blocks or slabs (9 in. by 9 in.) of the same thicknesses two at a time ; or six bricks of standard size at one operation on one pallet. It is strongly constructed on a braced iron stand, has few working parts, and can be recommended for use where an efficient hand-machine is required. The pallets are interchangeable with the other " Winget " block-making machines. On this stand were also shown some samples of coloured concrete walling, some of the warm red tones being especially attractive. The colouring is applied as a slurry after the blocks have partially set.

THE " WESTMINSTER " BLOCK-MAKING MACHINE.

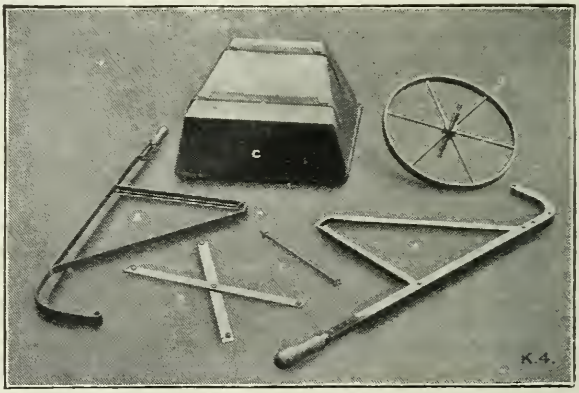
Messrs. Vickers, Ltd. (Broadway, S.W.1) showed machines for the manufacture of concrete slabs, bricks, and tiles. These machines are all light and portable, designed for hand operation, and the demonstrations that were given proved that they are capable of large outputs. On the slab machine, hollow or solid blocks for partitions, walls, or pavings are made with either square or groove-and-tongue joints. On the tile machine, waterproof concrete tiles of any colour are produced. The tiles are interlocking, and are considerably lighter than clay tiles—7 cwt. per square of roofing as against 12 cwt. The brick-making machine is designed to make concrete bricks of standard sizes, but by simple adjustments will produce arch bricks, floor bricks, tiles, etc., without the use of additional apparatus. It is claimed that 2,000 bricks per day can be manufactured on this machine.

A large variety of products for treating and increasing the efficiency and adaptability of concrete was exhibited by *Messrs. Building Products, Ltd.* (44–46, King's Road, S.W.3.) including the following waterproofing and structural specialities : " Bareau " waterproofing powder ; " Prufit " waterproofing paste ; " Prufitol " brick, stone, and stucco waterproofer ; " Fillertex " plastic crack and joint filler ; and " Fibrad " bituminous dampcourse. Among the specialities for use in factories were " Rigifix " bolt hanger sockets and slotted inserts, by the use of which the expense of cutting concrete to take belt drives, machinery, etc., is obviated ; guards for the protection of concrete columns and curbs ; " Ferrolithic " floor hardener and dust-proofer ; " Aqualithic " liquid dustproofer and hardener for existing concrete floors ; and " Fibrad " three-ply roofing in rolls. There were also shown bar-bending machines, mould oil, spraying machines, and drum and can tilters. The " Universal " spraying machine was also shown, by means of which waterproofing liquids can be applied to walls of any height with a minimum of labour and time.


The " Universal " Spraying Machine.

Bar-bending machines especially designed for shaping reinforcing rods for concrete construction were shown by *Mr. W. Kennedy* (Station Works, Warwick Road, West Drayton). These machines are strongly and simply built and light in weight, and the presence of one of them on a reinforced concrete job will often prevent vexatious delays when rods of the required shape are not to hand. The machines were shown in three patterns: (1) a machine weighing 25 lb. to bend rods up to $\frac{5}{8}$ in. diameter ; (2) a geared machine to bend rods up to 1 in. diameter ; and (3) a worm geared machine to bend rods up to $1\frac{1}{2}$ in. diameter. The machines will all bend cold bars of the sizes mentioned to any given measurement.

An interesting series of labour-saving plant was shown by *Messrs. Builders' and Contractors' Plant, Ltd.* (15, Victoria Street, S.W.1). Two types of the " Exe " hoist were erected on the stand, and demonstrated the possibilities of such devices in saving labour and speeding-up building construction by the rapid hoisting of materials. The hoist can be easily erected wherever there is existing scaffolding, and in this connection the efficiency of the " Fircrete " timber clip was practically demonstrated. The value of the hoist is considerably enhanced by the fact that its height can readily be increased as the building progresses, and by the revolving head which enables the platform to be swung in at the required height so that the barrow may be wheeled on at the ground level and off at the top without extra handling. The hoist is fitted with a jib for handling bulky loads, and an automatic stopping device. Two portable " Roll " concrete mixers were on view, each fitted with an oil-engine. These strongly-constructed machines have automatic loading and water-supply devices. A new concrete block-making machine —the " Ama," provided with a spring-regulated mechanical tamper, was shown in operation, and also a hand tipping cart and the " Klipit " light steel hand barrow, which can be taken to pieces in two minutes and stored in a very small space.

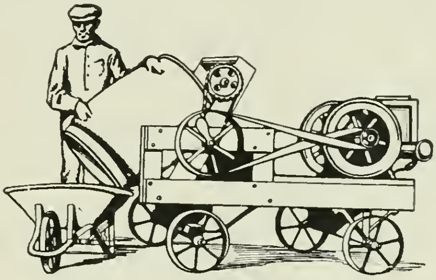


The " Klipit " Steel Barrow.

The "Australia" concrete block-making machine and the "Tonkin" mixer were shown at work on the stand of the *Australia Concrete Block Machine Syndicate* (607, Salisbury House, London Wall, E.C.2). The "Australia" machine is now well known as a handy and efficient machine, and turns out blocks at the rate of 350 T-shaped faced blocks or 450 breeze slabs per day. The "Tonkin" mixer is a new product of this Company, and was recently illustrated and described in this Journal. Both these machines have an output sufficient for the largest jobs, while their cheapness in first cost and running costs render them a paying proposition for even the smallest contract. They were working under practical conditions at the Exhibition, and fully justified the claims put forward for them.

Messrs. Parker, Winder & Achurch, Ltd. (Broad Street, Birmingham) showed the "Empire" concrete mixer. The engine and drum are mounted on a wooden framework which permits of the drum being turned so that it will discharge to the front or sides. The engine is fitted behind, and the drive is through two bevel gears, one at each end of the vertical rod that connects the drum with the engine shaft. The drum is easily tilted to discharge the contents by means of a lever at the side. A very strong screen was shown by this firm, which should be very free from clogging.

PARKER, WINDER & ACHURCH



"EMPIRE" CONCRETE MIXER.

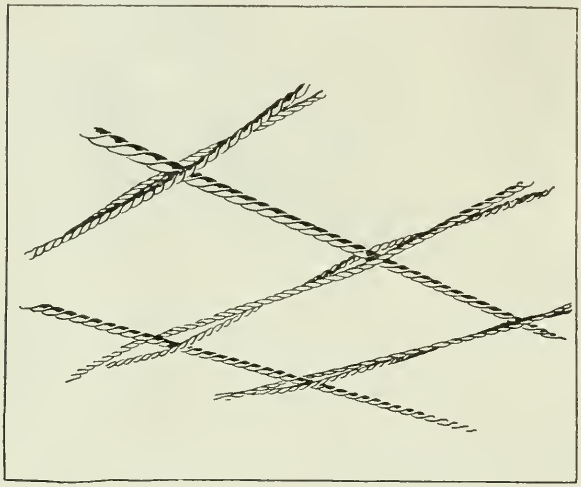
A useful labour-saving device, the "Liner" concrete block-making machine and elevator, was shown by the *Liner Concrete Machinery Co.* (Newcastle-upon-Tyne). The combination consists of a strongly-made and simply-operated mould and an elevator mounted on rails, by means of which the finished blocks or slabs are transported direct from the mould to the curing ground without being handled. The mould is 6 ft. long by 13 in. wide by 10 in. high, and will turn out slabs of this size for lintels, etc., or can be divided into any number of smaller compartments for the manufacture of blocks, quoins, etc. On large contracts the combination should result in a considerable economy in labour being effected.

Various block-making machines, adapted for forming any shape of block, coping, channelling, etc., either solid or hollow, were shown by the *Martin-Harvey Engineering Co.* (116, Victoria Street, Westminster, S.W.1). The *Manelite Patent Concrete Machinery Co.* (Bournemouth) exhibited an hydraulic block-making machine. A new block-making machine, which is claimed to be one of the cheapest on the market and is built on sound and practical lines, was shown by *Messrs. H. and J. West & Co., Ltd.* (72-4, Grays Inn Road, W.C.1). The "Bayliss" double-acting type block-making machine was shown by *Messrs. W. Bayliss & Co., Ltd.* (240-1, Dashwood House, New Broad Street, E.C.2). A machine that will turn out lintels up to 7 ft. long, or a number of smaller blocks at one operation by the insertion of liners, was shown by *Messrs. R. H. Kirk & Co.* (Newcastle-on-Tyne). In addition to the well-known "Ironite" brand of cement, *Messrs. S. Thorneley Mott & Vines, Ltd.* (11, Old Queen Street, S.W.1) exhibited a useful concrete mixer ("The Wonder"), a dumping wagon, and "Aero" concrete blocks. *Messrs. Henry Wilde, Ltd.* (66, Victoria Street, S.W.) showed a wide range of power machines for making concrete blocks, especially noticeable being a power tamping machine which strikes a blow of 700 lb. at the rate of 70 a minute.

The "Dussitorl" (Commander Thomas's patent), (227 and 228, Tower Buildings, Water Street, Liverpool) is a new machine, substantially made and easy to handle. In it, there may be made at one time either twelve concrete bricks, two 18 in. × 9 in. blocks, or a sill, lintel, head, step, etc. It is a face down machine, so that a layer of rich facing concrete may be placed in the bottom and a leaner mixture or a mixture containing a porous aggregate tamped on top of it. As a semi-dry concrete is used the blocks, etc., may be removed at once from the machine and, by a patent device, immediately placed upon their ends to mature. This machine is being used on the Liverpool Housing Scheme.

REINFORCEMENT.

The uses of the "Keedon" and "Lattice" reinforcements were effectively displayed on the stand of *Messrs. Johnsons' Reinforced Concrete Engineering Co., Ltd.* (Lever Street, Manchester). The "Keedon" system, which is extensively used for reinforced concrete structures, is on the wedge principle, and combines the advantages of rigid yet adjustable members with a non-slipping bar; the fact that the members are held in position with simple wedges permits of rapid erection to any design. The "Lattice" is in the form of rolls, suitable for floors, roads, etc. "Brictor" netting, for the strengthening of ordinary brick walls, was also shown, and its efficiency demonstrated by a section of 4½ in. wall laid flat across a 7-foot span.


"B. & T." Reinforcement.

A new type of wire mesh reinforcement was exhibited by *Messrs. Brown & Tawse, Ltd.* (3, London Wall Buildings, E.C.2). The material, which is designed for road foundations and other forms of concrete construction, is manufactured from mild steel wire, cold twisted in order to eliminate the first stretch and thereby raise the tensional resistance of the metal. The twisted formation of the wire ensures a firm bond with the concrete. When used on large areas the network is joined together by pieces of the twisted wire supplied for the purpose, and there is no need to waste material by overlapping; in fact, the wires used for jointing form part of the run of the material, and thereby effect a considerable economy. A further feature of "B. & T." reinforcement is that there are no projecting wires at the ends or sides, which sometimes lead to claims for compensation for torn hands on the part of the workmen. The wires are not specially fastened where they cross, but their spiral formation ensures secure locking when the network is stretched taut.

In addition to their "Diamond Mesh" expanded metal reinforcement for roads, floors, etc., and "Exmet" reinforcement for brickwork, the *Expanded Metal Co., Ltd.* (York Mansion, Petty France, S.W.1) exhibited a new type of reinforcement, called "Rotary Diamond Mesh" expanded steel. Like the "Diamond Mesh," this is also designed for road, floor, roof, or other slab reinforcement, and is supplied in rolls up to 60 ft. in length and 4 ft. 1½ in. in width.

CEMENT AND WATERPROOFING MATERIALS.

The *Cement Marketing Co., Ltd.* (8, Lloyd's Avenue, E.C.3) showed a selection of samples of the cement products of the Associated Portland Cement Manufacturers, Ltd., the British Portland Cement Manufacturers, Ltd., Martin Earle & Co., Ltd., and the Wouldham Cement Co., Ltd., for which it is the selling organisation. In addition to the samples of cement in various stages of manufacture, and cubes prepared for testing purposes, there was a complete set of testing apparatus used in connection with the requirements of the revised British Standard Specification, and practical tests were carried out on the stand. A hydraulic crushing machine, reading up to 50 tons, was shown in operation. Samples were also shown of lime, whiting, superfine Keene's and Parian cements and coloured concrete.

The well-known cement waterproofing powder, "Pudlo," was exhibited by *Messrs. Kerner-Greenwood & Co., Ltd.* (King's Lynn), and models were shown to demonstrate its application, as follows:—(1) Apparatus for testing the resistance of cement to permeation by water under pressure; (2) a section of concrete flooring with a waterproofed cement layer 1 in. thick on the upper surface; the lower part of the slab, made of porous concrete, was immersed in water, while the top remained perfectly dry; (3) a length of drain-pipe jointed with cement and "Pudlo," which held water with no sign of leakage; and (4) a tank built of thin porous blocks faced inside with waterproofed cement one-quarter inch thick, which also held water with no sign of dampness on the outside face. In addition to structures such as tanks, sewer tubes, artificial lakes, etc., wherein the concrete is continually covered with water, "Pudlo" is largely used for the cure of damp walls, flooded cellars, etc., and for the construction of dampcourses, and these applications of the material were also shown in a practical manner by models. A section of the stand which attracted considerable interest was an exhibition of some of the original sketches by well-known artists of the artistic designs used by Messrs. Kerner-Greenwood in their advertisements in this and other journals.

Messrs. Super Cement, Ltd. (10, Upper Woburn Place, W.C.1) demonstrated the water and oil-proof qualities of their specialities by practical exhibits, among the more interesting of which were some trays made of porous concrete which were rendered capable of holding water without the slightest trace of any leakage by brushing over the inside with a slurry of "Super Cement." The very high crushing strength of the material was shown by a specimen of "Super-Cement" and sand under hydraulic pressure.

The value of their products for improving concrete was demonstrated on the stand of the *Torbay & Dart Paint Co., Ltd.* (26–28, Billiter Street, E.C.3), including "Novoid," "Everok," and "Rencrete." "Novoid" is a powder which has a chemical action on Portland cement and renders concrete water and oil proof by filling the voids with insoluble silicates; "Everok" is a colourless solution that has a similar action on cement to the first-named, and is intended to prevent concrete floors from "dusting," as they are liable to do if not properly laid; "Rencrete" is a similar solution, but specially prepared for water-proofing concrete, brick, plaster, etc. This solution is supplied in various colours, and can be used for the decoration of existing work while at the same time rendering it weatherproof. The void-filling properties of "Novoid" were demonstrated beyond dispute by samples of treated and untreated concrete under microscopes, which gave visual evidence of the difference claimed.

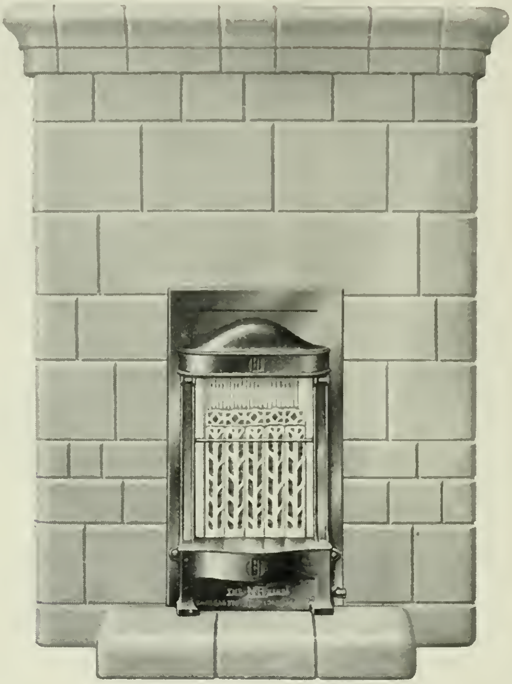
On the stand of the *Adamite Co., Ltd.* (Regent House, Regent Street, W.1) was shown "Anti-Hydro" cement waterproofing material. This waterproofer has a base of calcium chloride, which is neutralised by carbon compounds introduced through a special process. It is claimed to have no acid reaction, and not to have any electrolytic action on steel. "Atlas" white cement was also shown on this stand.

GENERAL.

The application of concrete to the drainage and sewage purification of a country house was admirably demonstrated by *Messrs. Tuke & Bell, Ltd.* (27, Lincoln's Inn Fields, W.C.2), in the form of a model of a complete installation for such a purpose. This system consists of a concrete liquefaction tank, made in sections so that it can readily be put together on the site with a concrete cover in two pieces. The humus settling chamber is fitted with concrete baffle and weir plates.

CONCRETE PRODUCTS.

A large assortment of concrete products were exhibited by The *Croft Granite, Brick, & Concrete Co., Ltd.* (Croft, near Leicester), including dressings for window frames, tubes for drainage, kerbs, heads, sills, flags, bases for gas stoves and cookers, reinforced beams, high-tension switch cells for electrical equipments, etc. This stand was quite a revelation as to what can be achieved in concrete, and the firm is now turning out well-designed window-frames in concrete on mass production lines. Especially noticeable was a very fine series of garden ornaments, that would add to the beauty of any park or garden. The firm also exhibited a concrete mantel.



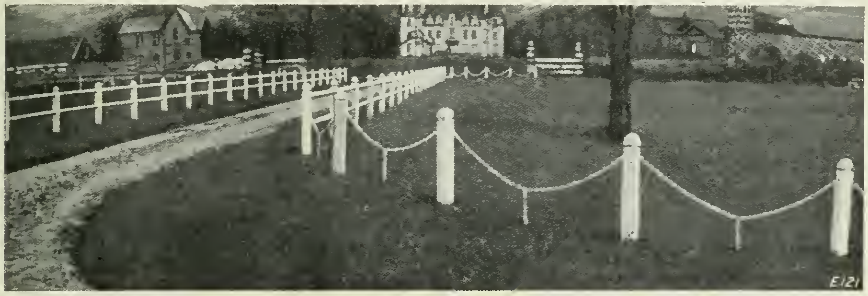
The "Nautilus" Concrete Mantel Register.

An exhibit of special interest now that the cost of working-class houses is receiving so much attention was that of *The Nautilus Company* (60, Oxford Street, W.1), who demonstrated the saving that can be effected by the use of built-in gas fires and the elimination of chimney breasts and large flues. The face of the fire is built flush with the surrounding wall, and an escape for the fumes is provided by a small flue formed of pre-cast hollow concrete blocks. A further interesting feature on this stand was a concrete mantel in which one of the gas fires was set. This innovation, well-proportioned and moulded and cast in one piece, makes a welcome change from the stereotyped metal or tile surround, and its relative cheapness combined with its good appearance should assure it of a big future not only in the housing schemes but also in large houses, offices, etc.

A good display of reinforced concrete fencing posts and railings was shown by *Messrs. C. R. Building Constructions, Ltd.* (19, Castle Street, Falcon Square, E.C.1). There is, of course, no comparison between the durability of concrete posts and that of wooden posts, and the periodical painting required by iron and wood posts is a further factor in favour of concrete, the cost of upkeep of which is *nil*. When it is stated that the prices per yard quoted for these concrete railings are less than for other types of railings, they cannot fail to commend themselves to estate managers, farmers, and others, to whom the maintenance of whatever method is adopted for enclosing land is no inconsiderable sum. Further, the posts and rails may be had from stock. The Company also supplies concrete gates, both of artistic designs suitable for park entrances or plain.

A large assortment of concrete sewer tubes, up to 6 ft. internal diameter, radial tubes, bends, junctions, tapers, gulleys, manholes, etc., were shown by *Messrs. Sharp, Jones & Co.* (Bourne Valley Works, Parkstone, Dorset), and admirably demonstrated this branch of concrete work. These tubes are not reinforced.

The "Hume" reinforced concrete tube was shown by the *Stanton Ironworks Co., Ltd.* (Stanton), in sizes up to 5 ft. diameter.



"C.R." Reinforced Concrete Railings at Entrance to Chateau in France.

EDUCATIONAL.

The stand of the *Concrete Utilities Bureau*, of 35, Great St. Helens, took the form of a bungalow carried out in Tudor style. As this organisation exists for propaganda purposes in the interests of concrete, the display was not spectacular, but a good deal of useful information could be obtained either from the representatives in attendance or from the range of pamphlets which are issued for free distribution. The latest of the series (No. 14) deals with the artistic possibilities of concrete, especially with a view to showing the variety of pleasing effects, both as to colour and texture which can be obtained by the simple method of scrubbing or tooling the concrete surface before it has become thoroughly hard. This is the first of the Bureau pamphlets to be illustrated with coloured plates.

Other publications which could be obtained at the stand were the recently issued book entitled *Concrete Roads*, the volume *Concrete Cottages, Small Garages and Farm Buildings*, a new edition of which is now in the press, and the monthly journal *Concrete and Constructional Engineering*.

A CONCRETE ROAD CONSTRUCTED FOR HEAVY TRAFFIC.

The road here illustrated was constructed by Messrs. G. & T. Earle, Ltd., at their Cement Works, Wilmington, Hull, for the heavy motor and rully traffic passing through their works.

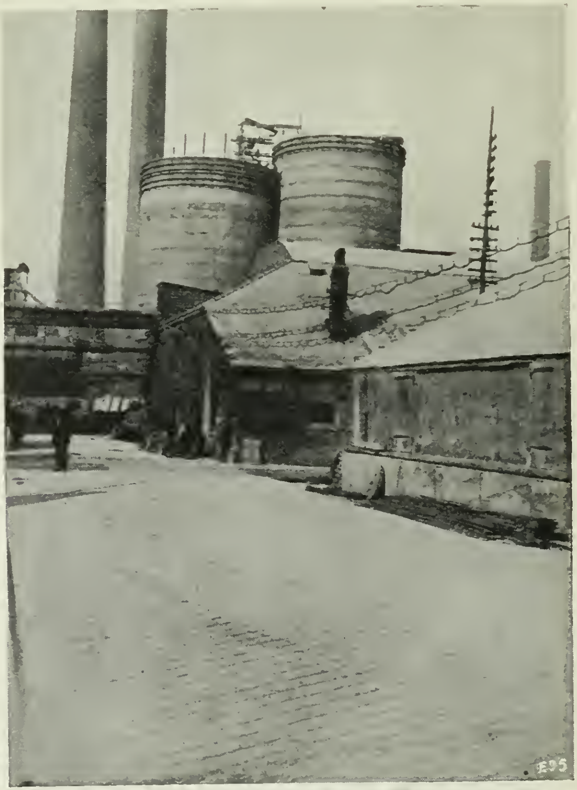
The method of construction was as follows :—

The old road was taken up and all soft earth removed till a solid foundation was found. Then 12 to 18 in. of solid filling—chiefly old broken concrete—was put in, the voids being filled up with small material. On top of this filling concrete consisting of gravel, sand and cement in the proportions of 5 : 3 : 1, 6 in. thick, was placed. This concrete was left rough in order that the wearing surface should key into it, and the wearing surface was placed on this before the final set had taken place. The wearing surface consisted of concrete made from Whinstone chippings and cement in the proportion of 5 to 1. The Whinstone Chippings were half inch and under, and the dust was so proportioned that no sand was necessary.

The surface was V'd as soon as the concrete had stiffened sufficiently to allow this ; this is seen in the illustration, a square steel bar with turned up ends being used for this purpose.

All the concrete used on this work was hand mixed and hand rammed, the greatest care being taken in the grading and proportioning of the aggregate, and the smallest possible quantity of water was used.

The greatest importance was also attached to obtaining a solid foundation, and to the quick handling of the concrete.



Concrete Road at Wilmington Works Hull, with Concrete Silos and Concrete Chimney in background.

CEMENT NOTES.

By Our Special Contributor.

The Storage of Cement.

It has been previously shown (see this Journal, Vol. XVI, p. 131) that when cement has to be stored for a period of months, or even years, preservation from deterioration is best secured by emptying the sacks and storing the cement loose in bulk when the formation of a thin crust on the surface prevents the absorption of moisture by the cement as a whole. Prolonged storage is, however, rarely anticipated and consequently the emptying of the sacks is seldom done. The problem confronting the ordinary user is, therefore, how should cement in sacks be stored so that no deterioration will occur should it become necessary to keep it for two or three months ?

The fundamental condition is, of course, that the storage building should be damp proof and weather proof, but this is really not enough, because the atmosphere always contains some moisture, no matter what the season or the temperature may be, and the affinity of cement for water is so strong that absorption of moisture, with consequent deterioration in quality, is bound to occur so long as the cement is in a changing atmosphere. It follows, then, that the more nearly airtight the building provided for cement storage can be kept, the less will be the effect on quality during storage.

Where storage of a temporary character is required, as on a contract, wooden sheds can be made to serve the purpose. The floors should be raised above the ground and are preferably constructed with a double layer of boards with tarred paper between. The walls also may be made damp proof with one or more layers of tarred paper applied internally, while the roof should be externally protected with tarred felt. The doors should be tight fitting.

Where the provision of a permanent cement store is needed, a concrete building should be considered, but the concrete must be dense in order to be waterproof, and such a building should be allowed to dry out thoroughly before it is used.

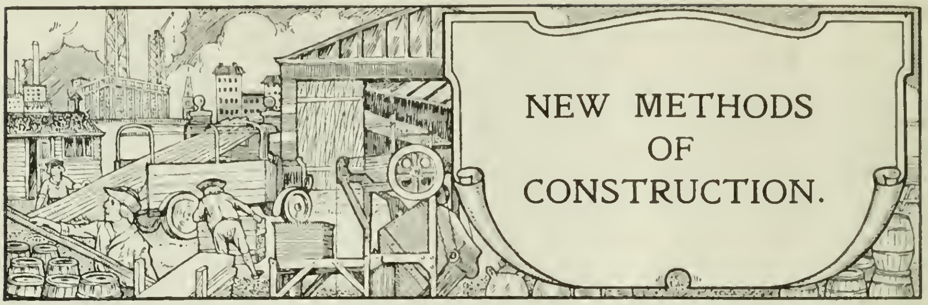
When storing cement in sacks, the latter should not be in contact with the walls of the building, but at the same time there should be as little free air space as possible. The sacks should also be kept from contact with a concrete floor by boards for battens until the concrete is several months old.

If the sacks of cement are piled several tiers high, the pressure upon the lower sacks is sufficient to consolidate the cement into fairly hard cakes, but this caking disappears on rolling the sack on the floor and should not be mistaken for air-setting due to absorption of moisture.

When a cement becomes damaged by absorption of moisture, the result is seen in the formation of lumps and the cement is usually slow in setting and in hardening. In bad cases of damage, the cement never attains a satisfactory strength, but where the amount of moisture absorbed does not exceed 4 per cent., the hardening is merely retarded and the strength in two or three months is normal. A cement user or merchant who has the misfortune to possess cement damaged by storage should have the cement tested by an expert or by the manufacturer, either of whom will advise whether the lumps should be screened out and discarded, or whether an additional proportion of cement should be embodied in concrete to provide a normal strength.

MEMORANDUM.

Metal Forms and Economy in Paint.—In the construction of a large reinforced concrete building for the Columbia Gramophone Co., at Baltimore, steel forms were used throughout. The surfaces of the columns and ceilings were afterwards painted, and owing to the smooth finish obtained by the use of the steel forms the amount of paint required was only half the quantity which it was originally estimated would be necessary. Steel forms are being extensively used in America for all descriptions of concrete work, with, it is stated, a considerable economy as compared with wooden formwork.



NEW METHODS OF CONSTRUCTION.

In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.—ED.

THE ANCHOR-TIE SYSTEM OF WALL CONSTRUCTION.

THIS system, which may be adapted to either solid or cavity wall construction, consists essentially of two leaves of pre-cast concrete 3-in. slabs, with a cavity between. This cavity may be filled with poured concrete, thus forming practically a monolithic wall, or a cored concrete tie may be laid which could be continuous throughout the wall and so form closed chambers in each course, or the ties may be arranged in series so as to form a continuous air space from damp course to roof.

Before laying the tie, a strip of cement asbestos sheeting is placed across the cavity, and upon this the material for the tie rests.

The two thicknesses of slabs are placed on the wall dry, one course at a time, each slab being separated from the one below by small pieces of concrete or other suitable material, so that a space is left which is eventually filled with the concrete poured from the inside which forms the joint.

The dry built slabs are held in position by metal clips until the poured concrete has set. Although not required at every joint, the slabs being securely tied together by the poured concrete, metal ties are preferably used in the courses on which the roof and floor joints rest.

By running a reinforced steel bar just over the cross ties longitudinally throughout the wall a great increase in strength is cheaply obtainable which might be of great advantage in mining districts where settlements are likely to occur.

The following are the claims made by the inventor of this system, Mr. Thomson :—

1. The novel form of building slab enables unskilled labour to bed and joint the slabs better with poured concrete than the skilled workman could with trowel and mortar.

2. The poured concrete also carries the joists and so evenly distributes the floor, roof and other load stresses over both thicknesses of the wall that it thereby correspondingly increases the stability of the entire structure.

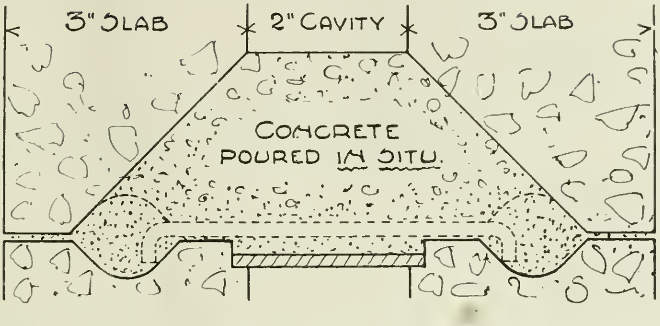
3. Compared with an 11-in. hollow brick wall the 8-in. cavity concrete wall has much greater lateral stability, and in semi-detached houses gives 6 per cent. more habitable space in each dwelling, and as this form of solid wall with 6 : 1 casing slabs and a continuous waterproofing core need only be 7 in. thick, it gives 8 per cent. more space in the habitable apartments than the brick-built dwelling.

4. With the foregoing advantages in its favour concrete, wherever suitable aggregates are available, offers dry walled dwellings at considerably less cost than brick-built houses.

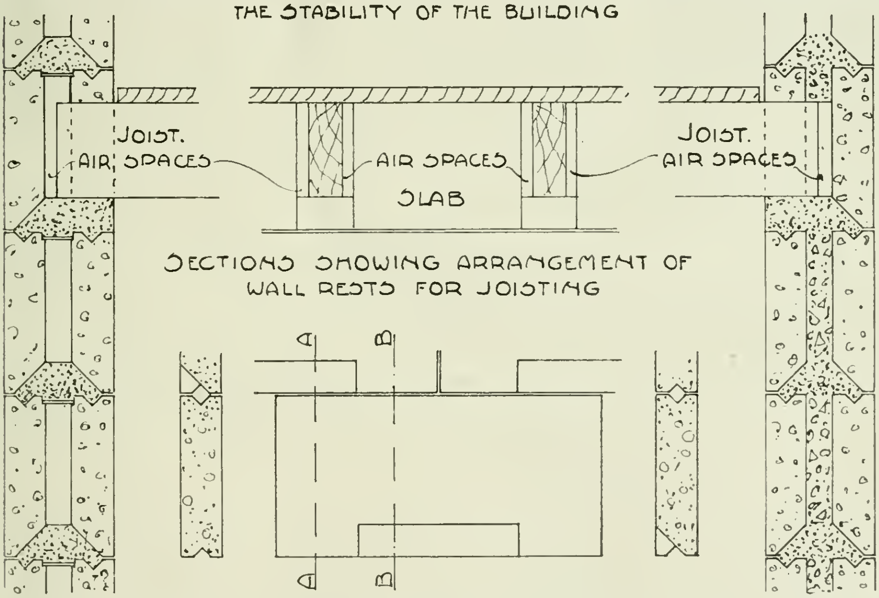
The walls as shown meet the standardised requirements of the Ministry of Health.

5. Another feature is that the cross ties are more than $1\frac{1}{2}$ in. from the face of the wall. These ties automatically grip the sloping sides of the groove in the upper bed of the slab.

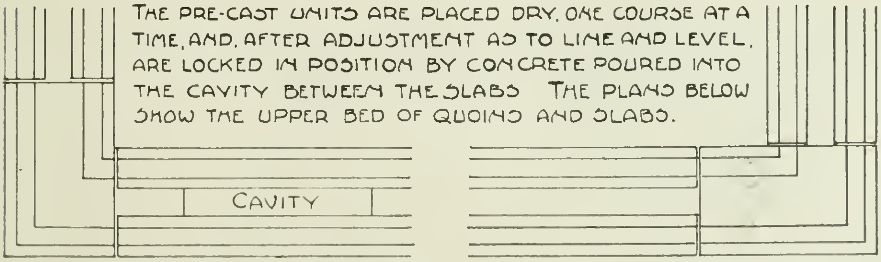
Patent applied for



The poured concrete efficiently beds and joints the pre-cast concrete units. Rigidly ties the outer and inner thicknesses of slabs together thereby giving what is in effect a monolithic structure. Carries the joists. Distributes the stresses, due to roof and floor loads, over both thicknesses of the wall and thus correspondingly increases the stability of the building



Sections showing arrangement of wall rests for joisting



The pre-cast units are placed dry, one course at a time, and, after adjustment as to line and level, are locked in position by concrete poured into the cavity between the slabs. The plans below show the upper bed of quoins and slabs.

Robert Thomson Architect, Staple House, 52 Chancery Lane, London. W.C.2.

B.S.P. CHATS

ENTERPRISE the Soul of BUSINESS.

Among all Engineers and Contractors who are in any way associated with Pile Driving operations, the name of THE BRITISH STEEL PILING COMPANY stands pre-eminent for their enterprising methods of doing business.

As Pioneers in this country in the use of Steel Sheet Piling instead of Timber piles, Enterprise and Determination to be satisfied only with the best that money can buy or brains devise, have in a comparatively short time completely revolutionized this branch of Engineering.

The Spirit of Enterprise shows itself in many directions. To mention one, and by no means the least—the readiness with which we take on our own shoulders the solution of the technical difficulties underlying so many pile driving propositions, placing the whole of our accumulated knowledge and experience at our Clients' disposal.

In Pile Driving and Withdrawing Plant we stand unrivalled, our name upon it guarantees it to be the most scientific and up-to-date plant obtainable.

We receive many expressions of approval from every part of the world, both as to our methods, our manufactures and our publications. The latest is from a well-known Public Authority Engineer in Australia, who writes under date March 16th, 1921 :—

"Your splendid little 'B.S.P.' Pocket Book has just reached me. Please accept my best thanks for same. I cannot but admire the enterprise that prompts a business house to advertise in this way."

Several Thousands of this Book have been distributed.

HAVE YOU HAD ONE? IF NOT, WRITE TO

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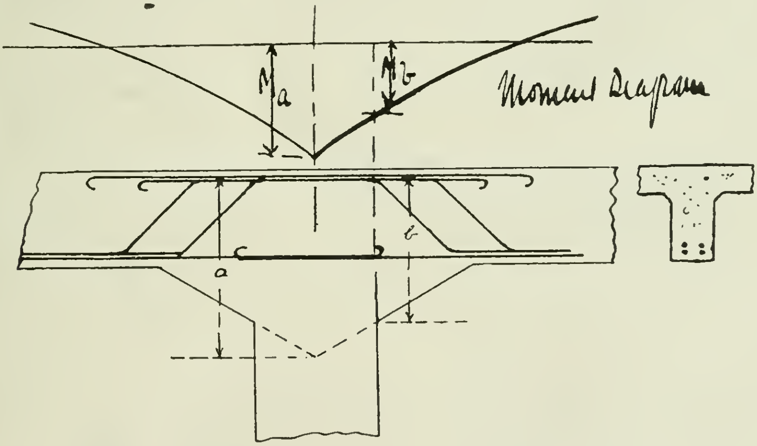
QUESTIONS AND ANSWERS RELATING TO CONCRETE.

In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.

Question.—V. W. writes :—In the case of a T*-beam, continuous over a number of supports, when, as is usual, the beam has to be increased in depth at the supports to get sufficient area of concrete in compression to safely resist the max. negative B.M. there, in practice would the effective depth " d " be taken as " a " or " b," see sketch ?*

Answer.—Whether the depth should be the full depth (*a*) in sketch, or the depth (*b*) at the bottom of the haunch where it joins the large column, depends entirely on what moment has been taken. If the moment allowed for has been M_a, that is the maximum reverse moment which can occur on the centre line of the support, then it would be quite justifiable to calculate for the full depth (*a*) as shown on the sketch. Conversely, if the bending moment at the support has been reduced to allow for the width of support and is taken equal to M_b as in the moment diagram which has been added to the sketch in question, then the depth should be taken as equal to (*b*) in the sketch. As a rule, in practice the same result is obtained whichever of these two methods of calculation is adopted.



(*Continued from page* 320.)

ample resistance can be provided. The foundation on the lower side must be built at a suitable depth and subjected to a light load. The foundation on this upper or valley side should be built in such a manner as to be dependent on the size of the base.

The value of this method of construction lies in the enormous resistance to pressure of the main wall and to the very small changes in volume of the reinforced concrete. Moreover, if through any carelessness in construction any part should give way repairs are much easier than in solid masonry or mass concrete.

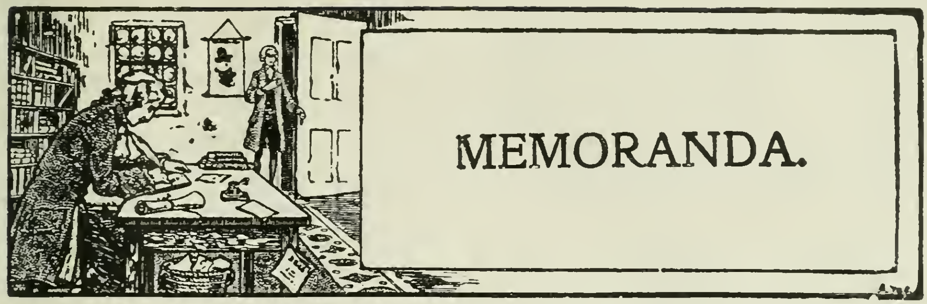
The construction is such that all leakage is confined to the permeability of the materials used and to errors in building. Any part of the structure may be readily examined. Turbine supply pipes may be much shorter than with mass construction. The saving in cost depends on relative prices of the materials used for mass and reinforced concrete, but as only 40 per cent. of the material required for mass concrete is required, the saving is very considerable and probably averages 15 per cent. on the structure and about 50 per cent. on the cost of supply piping.

The Victoria
CONCRETE MIXER

Big Batches Delivered Quickly.

WHEREVER Concrete is required it can be produced quickly and economically, in large, thoroughly mixed batches, if the "Victoria" Concrete Mixer is used. The model illustrated here—one of a series giving outputs varying between 54 and 3½ cubic feet per batch—is particularly suitable for road building. The long arm saves much time and labour in handling, and possesses a delivery radius sufficient to meet all practical road building needs. For particulars of "Victoria" Concrete Mixers please consult Catalogue M.D. 103—free for the asking.

STOTHERT & PITT
LIMITED
(MIXER DEPARTMENT)
11, VICTORIA ST., LONDON S.W.1



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—Ed.

CONCRETE HOUSING SCHEMES.

Bexley.—The rapidity with which concrete houses can be erected is being demonstrated at Bexley, where houses have been built up to the roof level in nine days. The houses, which are being constructed on a concrete block system devised by the Clerk of the Works to the Urban District Council, were commenced on March 2, and on March 13 the roofs were slated.

Glasgow.—It is reported that the Glasgow Corporation has invited a London firm of engineers to erect two experimental cottages on a special method of concrete construction, and that if the result is satisfactory as regards cost and speed of erection, the whole of the Corporation's housing schemes, estimated to cost £3,500,000, will be carried out on this system.

Glasgow.—In giving evidence before the Government Committee that is inquiring into the causes of the high cost of building in Scotland last month, Mr. Peter Fyfe, Housing Director of the Glasgow Corporation, submitted some information in regard to the use of concrete blocks for housing schemes. He stated that the Chief Surveyor to the Glasgow Housing Department estimated that a very substantial saving could be effected on the various types of houses by the use of concrete blocks amounting to £49 13*s.* 4*d.* for three-apartment flats, and £45 17*s.* 11*d.* for four-apartment flats per house. There was also a big saving in time and skilled labour ; only one-fourth of the skilled labour necessary for construction in brick was required for concrete block houses.

Ripon.—An interesting scheme is on foot at Ripon, where the Town Council has asked the Ministry of Health for permission to take over the concrete buildings erected for the Army at Bishopton for the purpose of converting them into working-class dwellings, to form part of the Council's housing scheme.

Sheffield.—As an objection on the part of the Housing Commissioner to the tenders for the concrete houses on the Mears Estate of the Sheffield Corporation, these tenders have now been reduced from £311,378 to £297,610, and have been accepted and amended.

PROSPECTIVE NEW CONCRETE WORK.

Burnley.—*Waterworks.*—The Burnley Corporation has received the sanction of the Ministry of Health to a loan of £50,000 for extensions at the waterworks.

Darlington.—*Waterworks.*—The Darlington Corporation is considering an expenditure of £114,000 on waterworks extensions.

Darlington.—*Waterworks.*—The Darlington Corporation has decided to apply to the Ministry of Health for sanction to a loan of £114,000 for extensions and improvements at the waterworks.

Dartford.—*Wharf.*—The West Kent Main Sewerage Board has received the sanction of the Ministry of Health to a loan of £212,663 for the extension of its wharf at Dartford, including £105,816 for reinforced concrete work.

Hartlepool.—*Sea Defence.*—A Ministry of Health inquiry has been held into the application of the Hartlepool Corporation for sanction to borrow £16,500 for sea defence works.

Leith.—*Docks.*—The Leith Dock Commissioners have prepared a scheme for the extension of the Docks at that town, at an estimated cost of £300,000.

New Zealand.—*Harbour Works.*—The Tauranga (New Zealand) Harbour Board has received an Order in Council authorising the expenditure of £125,000 for the improvement and development of the harbour.

Penrith.—*Bridge.*—The Penrith Rural District Council is considering a proposal for the erection of a bridge over the river Wath, at Ivesgill.

Preston.—*Waterworks.*—The Preston Rural District Council has received sanction to a loan of £13,850 for a water supply scheme at Farington.

Renfrew.—*Docks.*—The Trustees of the Clyde Navigation Trust have decided to proceed with an extensive scheme for the improvement of the docks at Renfrew, involving an expenditure of about £280,000.

Vancouver.—*Harbour Works.*—The Vancouver Harbour Commissioners are considering a scheme for the construction of a dam, locks, etc., at the harbour, at an estimated cost of three million dollars.

TENDERS ACCEPTED.

Belfast.—The Belfast Corporation has accepted the tender of Messrs. Concrete Piling, Ltd., for the construction of a new electricity generating station, at £76,833.

Bradford.—The Bradford Town Council has accepted the tender of the Expanded Metal Co., Ltd., for the reinforcement required in connection with the construction of concrete foundations at No. 4 Boiler House at the Valley Road Electricity Works.

Brentford.—The Brentford Urban District Council has accepted the tender of Messrs. W. Ashby & Son, of Greenwich, for the supply of 120 tons of cement, at £4 10*s.* 6*d.* per ton.

Harrogate.—The Harrogate Town Council has accepted the tender of Messrs. Hymas for the construction of a concrete floor at the electricity works, at £1,496 14*s.*

Leeds.—The Leeds Corporation has accepted the tender of Messrs. T. Ward, Ltd., for the supply of a concrete mixer at £120, and a stone breaker at £108, and the tender of the Cement Marketing Co., Ltd., for the supply of 230 tons of cement, at 98*s.* 3*d.* per ton, in connection with the construction of the Dewsbury Road Reservoir.

Lewisham.—The Lewisham Borough Council has accepted the tender of Messrs. The British Reinforced Concrete Engineering Co., Ltd., for 2,700 superficial yards of road reinforcement fabric, at 3*s.* 1*d.* per yard super.

London (Battersea).—The Battersea Borough Council has been recommended to accept the following tenders :—For supply of concrete breaker, Messrs. Goodwin, Barsby & Co., Leicester, £227 ; for concrete mixer, Messrs. Millars' Timber & Trading Co., Ltd., London, £300 ; concrete kerbing, Empire Stone Co., Ltd., London, £167 7*s.* 7*d.*

Muskham.—Messrs. Walter Scott & Middleton, of London, have been awarded a contract for the construction of a reinforced concrete bridge over the Trent at Muskham, near Newark. The cost will be about £50,000. The total length of the bridge will be about 300 ft., and there will be two spans of over 100 ft. each, supported by a pier in the centre of the river.

Plymouth.—The Plymouth Town Council has accepted the tender of Mr. W. J. Pearce for the erection of one pair of concrete houses on a special system of construction, at £815 12*s.* 6*d.* per house.

Romford.—The Romford Urban District Council has accepted the tender of Messrs. R. G. Ward & Co. for the supply of concrete tubes at the sewage farm, at 10*s.* 6*d.* per foot run.

Sheerness.—The Sheerness Urban District Council has accepted the tender of Messrs. T. W. Pedrette, of Bush Hill Park, Enfield, for the construction of about 2,640 lineal yards of egg-shaped concrete sewer tubes, from 2 ft. 9 in. by 1 ft. 10 in. to 9 in. diameter.

Sheffield.—The Sheffield Corporation has accepted the tender of Messrs. Holloway Bros., of London, for the construction of foundations and concrete flooring at the Damflash reservoir, on a cost-plus basis not to exceed £1,000.

Sheffield.—The Sheffield Corporation has accepted the tender of Messrs. Hadkin & Jones, Ltd., at £3,790 10*s.*, for the construction of the first portion of the reinforced concrete retaining wall and foundations in connection with the new Central Stores Depôt.

Wicklow.—The Wicklow Foreshore Committee has accepted the tender of Mr. John Kane, of Fitzwilliam Road, Wicklow, for the supply and laying of 80 large concrete blocks at the base of the pier.

Yeovil.—The Yeovil Town Council has accepted the tender of Messrs. Johnson's Reinforced Concrete Engineering Co., Ltd., for the supply of steel reinforcement in connection with the proposed new reservoir at Henford Hill, at £1,148 14*s.*

TENDERS INVITED.

Mansfield.—May 12. The Mansfield Borough Council invites tenders for the erection of 300 or a lesser number of houses. Plans, etc., from Mr. W. Thompson, Borough Engineer and Surveyor, Market Street, Mansfield. Deposit, £2.

Sidmouth.—May 16. For the erection of 56 houses, for the Sidmouth Urban District Council. Plans, etc., from Mr. R. W. Sampson, Architect, Manor Offices, Sidmouth.

Menston (Yorks).—May 18. For the erection of houses, for the Wharfedale Rural District Council. Plan, etc., from Mr. O. Holmes, Architect, Boroughgate, Otley.

Whitley Bay.—May 19. Erection of new Post Office, for H.M. Commissioners of Works. Forms of tender, etc., from Contracts Branch, H.M. Office of Works, 63, Westgate Street, Newcastle-on-Tyne, or King Charles Street, Westminster, S.W.1. Deposit, £1 1*s.*

Bramall.—May 24. For erection of 12 houses at Bramall, for the Hazel Grove & Bramall Urban District Council. Forms of tender, etc., from Messrs. Adshead & Topham, 23, King Street, Manchester. Deposit, £1 1*s.*

Bombay.—May 31. Construction of about 105 miles of steel and reinforced concrete pipe lines for the Bombay Corporation. Specifications, etc., from Messrs. Taylor & Sons, Consulting Engineers, 36, Victoria Street, Westminster, S.W. 1. Deposit, £100.

Pulborough.—June 30. The Pulborough Rural District Council invites tenders for the erection of 30 cottages. Plans, etc., from Mr. P. Ayling, Clerk to the Council, Storrington, Pulborough.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 6. LONDON, JUNE, 1921.

EDITORIAL NOTES.

A PLEA TO ARCHITECTS FOR COURAGE IN DESIGNING.

A CORRESPONDENT writing in a contemporary over the signature "Provincial Architect," whilst admitting the impossibility of trying to ignore and ban reinforced concrete, yet feels that its use, in the most efficient way, cannot but act to the eventual detriment of architecture. We feel that this fear is shared by many members of the architectural profession. The advent of a new means for the more efficient performance of an old function is always a matter of alarm to the majority. And as an analogy to this particular case the advent of the motor-car may be cited, when it was predicted that the charm of the horse equipage was to be supplanted by something hideous and quite incapable of achieving beauty. Yet now we see that a motor car has evolved a beauty of its own, equalling, if not surpassing, its predecessors. Furthermore, the ugly and badly-designed motors were just those early ones that endeavoured to simulate the form of the carriage; and it was only when they emerged from the tradition of the past (without altogether discarding that tradition) and evolved a form of their own, intrinsic with their manufacture and their purpose, that they became beautiful.

Reinforced concrete will only remain architecturally unsatisfactory just so long as its designers remain too self-conscious, and endeavour to perpetuate in a new material forms whose suitability belongs to others. The full possibilities of reinforced concrete are as yet unknown and untried, and it must be allowed time to evolve its own forms which will arise from its particular needs and limitations, and from its employment in the most efficient manner.

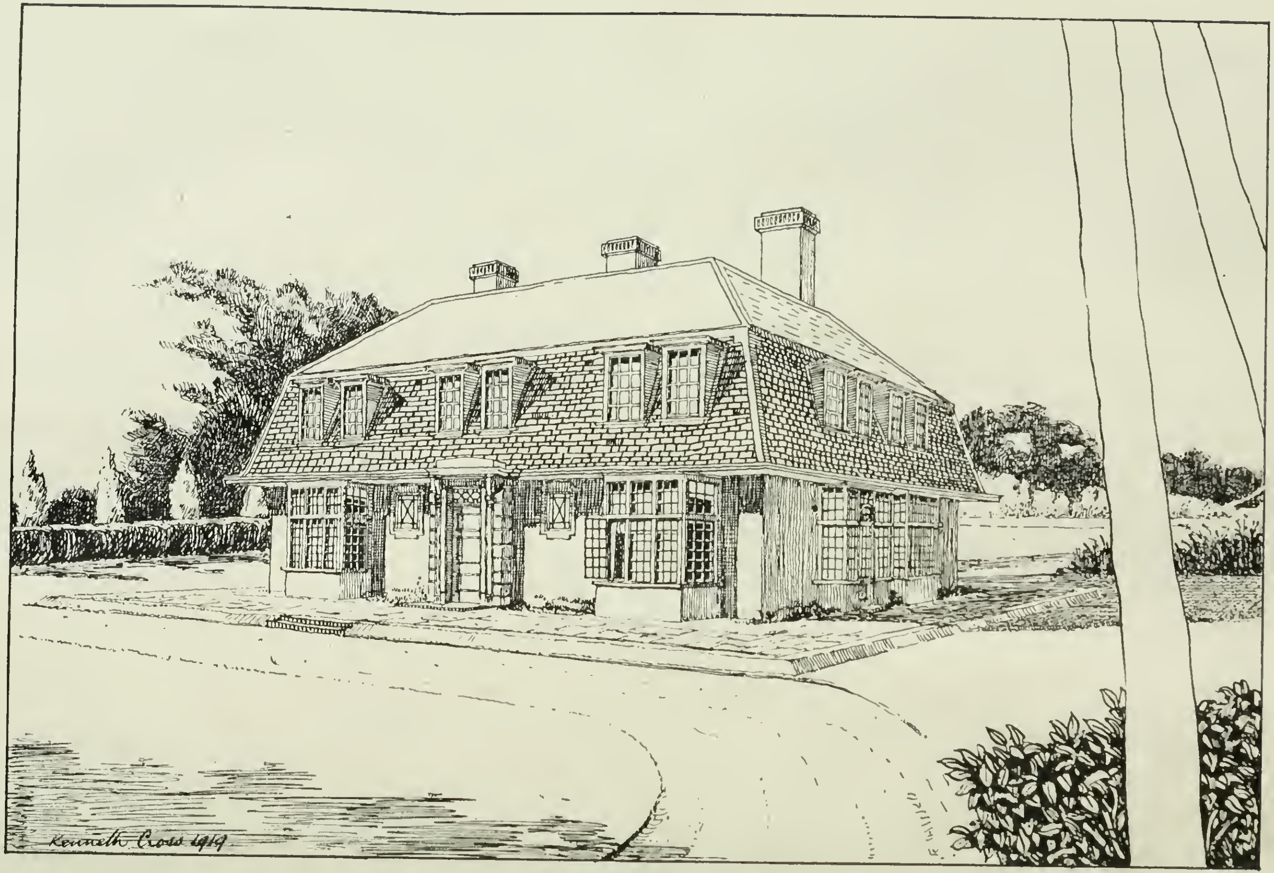
There are other aspects of the question. Architecture is subservient to the requirements of humanity, and a material the use of which has "brought light, airiness, cheerfulness, and comfort in working, into the lives of hundreds of thousands of people, whose lot it is to labour in those hives of industry" (factories) must be welcomed as an event of inestimable importance in the history of humanity. And a building that confers these great advantages cannot be devoid of the highest architectural merit beside which the shape of a moulding or the overhang of a cornice become matter of utter insignificance. No great architecture will ever be produced by talking about cornices and pilasters as if they are something extraneous to a building, to be added here, or omitted there. A cornice has a definite architectural function to perform; that of protecting the top of a wall, and a pilaster emerges where additional strength is wanted. The requirements of reinforced concrete have as yet to evolve, and these will develop into significant features as surely as they have done so in the past with other materials.

The factors that go to make æsthetic appreciation are many, but among the most important are historic association and familiarity. The former is largely responsible for the deplorable practice of selecting styles in which to design a building, and the latter so often compels the unnecessary addition of a cornice and a pilaster where neither is essential. These factors cannot, and should not, be ignored, but they must be made subservient to an infinitely greater and wider vision if a great and satisfying work is to be produced.

" Provincial Architect " deals at some length with the fitness of reinforced concrete for building factories, going so far, it would seem, as to show that the ideal requirements of this class of building have never been adequately met until this material made its appearance. He admits that the new factory is fit, since light, air, and unobstructed floor space are obtained, but because, in his opinion, the building is not also fine he seems to deplore the use of the material, while yet realising that it is the right material for the purpose, just as, to revert to our former analogy, others may, while admitting that the function of a vehicle is to transport persons or things from place to place with the utmost expedition compatible with safety, have feared and dreaded the use of the internal combustion engine as a driving power for locomotion. A little consideration will show that the objections of " Provincial Architect " are not radically architectural ; their origin is deeper. They refer to the requirements of a building which include the provision of large voids, of equally spaced floors carried upon equidistant supports, and the like, rather than to the building itself, and these requirements are the result of contemporary social organisation. The duty of the architect is not to dictate the purpose that his building shall serve, or the conditions under which he will attempt to provide such service, these things, to which he may or may not be sympathetic arise, from the industrial, sociological, and spiritual needs of the age.

Will a brick or a stone factory be more beautiful than one built in reinforced concrete ? It will not, because neither of the former materials are so suited to factory requirements. Can a factory be beautiful ? This is another and irrelevant question, which, interesting as it is, cannot be here dealt with, but it is the question indirectly raised by " Provincial Architect." Cannot a factory be beautiful unless it be made to look like a cathedral or a town hall ? Such a trend of thought leads nowhere—or everywhere ; absolute beauty in architecture cannot be considered apart from moral values. We may, and indeed should, obtain greater æsthetic satisfaction from the contemplation of a cathedral than a factory, because the former is expressive of finer aspirations than the latter, yet architecturally both may near perfection.

We admit that the problem confronting the architect who designs in reinforced concrete is a difficult one. The uses to which the material can be put are so diverse and its constructive limitations are so few. Limitations are necessary to the designer, and if they are not imposed from without they must be self-imposed. There will always be good buildings and bad buildings, whatever be the material or the building. But if the approach be pusillanimous the result will inevitably be worthless. The designer should be equipped with a sense of the past and of the great architectural traditions, both national and universal, and, of course, with a knowledge of the material with which he will build, but he must steadfastly refuse to think in terms of cornices and pilasters, for unless he does so he will never assist in the evolution of a great tradition for the new material which he is handling ; he will but deck it out in dead clothes.



[*Architects: Alfred W. S. Cross, M.A., F.R.I.B.A.; Kenneth M. B. Cross, M.A.*

House at Cheam, view from Burdon Lane.

(*For description, see page 353.*)

A CONCRETE HOUSE AT CHEAM.

WE have on many occasions illustrated and described houses built in concrete which should sufficiently refute the fallacious opinion, still held in some quarters, that a concrete house of architectural merit and distinction is impossible; the majority of the examples, however, except those of cottages, have come from America, where the prejudice against the material is almost non-existent; it is, therefore, with particular pleasure that we show this month an all-concrete house which is of completely English origin.

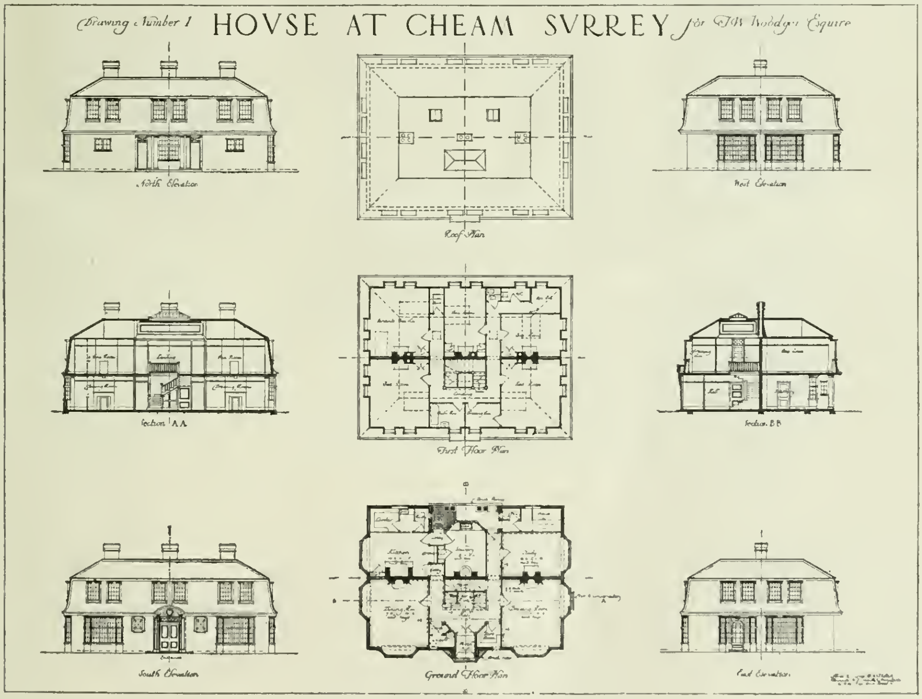


FIG. 1. ELEVATIONS AND PLANS.

The house was begun soon after the Armistice, and it was the difficulty in obtaining bricks in adequate quantities, coupled with the building owner's desire to have the work completed as soon as possible, that prompted the use of concrete. And, having decided to employ concrete as a substitute for brickwork, it was determined to construct the whole building in this material. The external walls are constructed with blocks made on a Winget machine. A 2-in. cavity is formed and the inner leaf is made of aggregate of a more porous nature than the outer. The blocks are tied with wall ties in the usual way.

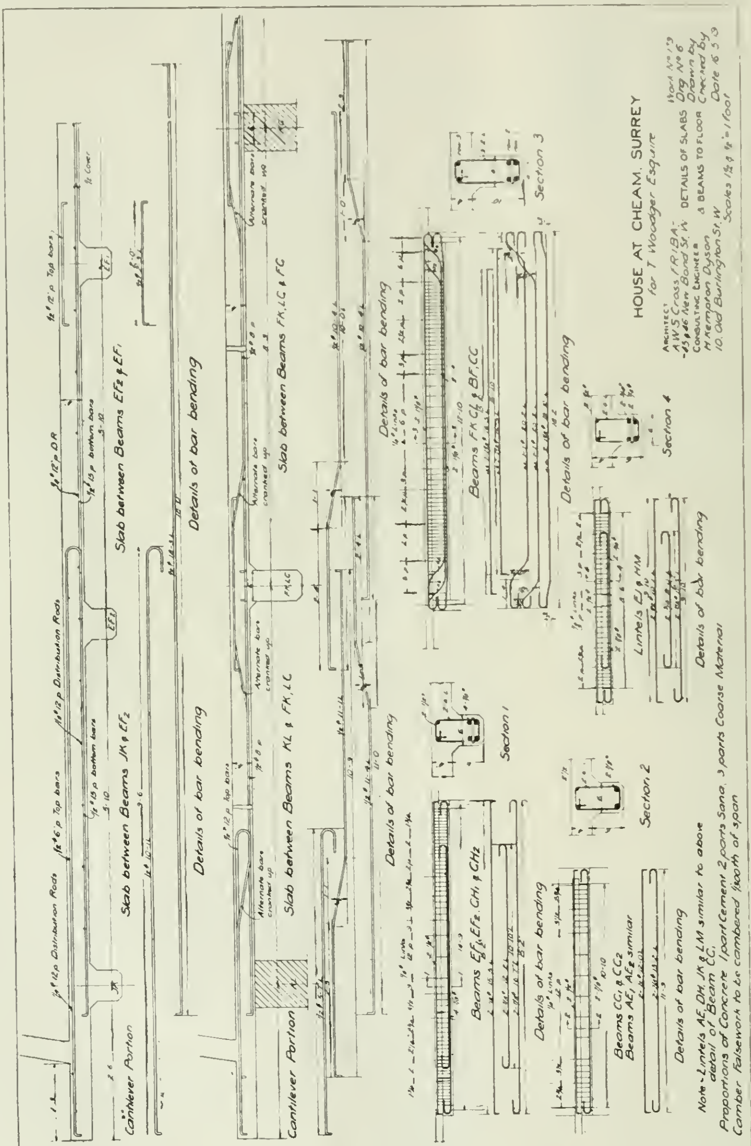

HOUSE AT CHEAM, SURREY
for T. Woodger Esquire
Architect A.W.S. Cross F.R.I.B.A. 45 & 46 New Bond St. W.
Consulting Engineer H. Kempton Dyson 10, Old Burlington St. W.
Details of slabs & beams to floor
Work No 13 Drg. No 6 Drawn by Checked by Date 16.5.13
Scales 1½ & ½" = 1 foot
Slab between Beams JK & EF2
Slab between Beams EF2 & EF1
Slab between Beams KL & FK, LC
Slab between Beams FK, LC & FG
Details of bar bending
Cantilever Portion
Beams EF1, EF2, CH1 & CH2
Beams FK, CL & BF, CC
Lintels EJ & HM
Beams CG1 & CG2
Beams AE1 AE2 similar
Section 1
Section 2
Section 3
Section 4
Note - Lintels AE, DH, JK & LM similar to above detail of Beam CC
Proportions of Concrete 1 part Cement 2 parts Sand, 3 parts Coarse Material
Camber Falsework to be cambered 1/600th of span

Fig. 2. Details of First Floor Construction.

Above the ground floor windows and at first floor level an unbroken cornice completely surrounds the house, above this springs the roof. This is the most interesting and enterprising feature of the design. In the first place it is a mansard roof: a roof form the more general adoption of which we have often advocated. Its advantages are many, and the fact that English builders have continually eschewed it constitutes an insular peculiarity for which it is difficult to account. Secondly, it is a form particularly suited to concrete, which admits of a much lower pitch than other coverings ; indeed, in this house the central part of the roof is flat, with merely a slight fall to carry off the rain. The roof being a homogeneous mass is, in fact, a self-supporting inverted basin. It was cast *in situ* between shuttering and is of course reinforced throughout. The first floor ceiling is suspended from the roof, and the intervening space acts as an insulator and thus maintains an even temperature. The flat portion of the roof is asphalted, the pitched portions are covered with slates on battens fixed to the concrete. The first floor is constructed with slabs and beams, and some of the working details in connection with these are shown in *Fig.* 2.

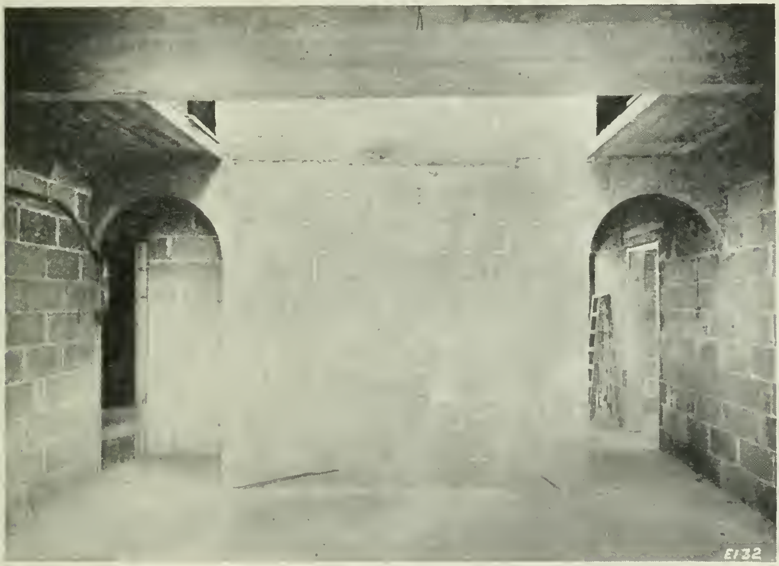


FIG. 3. A VIEW OF THE HALL DURING BUILDING OPERATIONS.

Turning now to the plan of the house, it will be seen that this presents many points of interest. The arrangement about two clearly defined axial lines is typical of planning which seeks to adjust itself to modern needs by a return to simpler and more dignified forms. It is, moreover, a form eminently suited to the method of construction. The shape of the hall, with its open oak staircase, the balance of the main rooms, and the grouping of the stacks along one of the axial lines are all points of interest. On the first floor the same balance is maintained in the disposition of the five bedrooms and the two passages. *Fig.* 3 gives a view of the hall, during building operations, in which the staircase well is seen and the arched openings leading to the lobby and to the verandah. *Fig.* 7 is a view from the front during erection ; concrete blocks can be seen in the foreground.

The half-inch and full-size drawings show the care that has been bestowed upon all the details whose treatment has a traditional basis but yet is redolent of originality, as for example in the fluting on the chimney stacks and the architraves to the small windows that flank the front door. The grouping of the

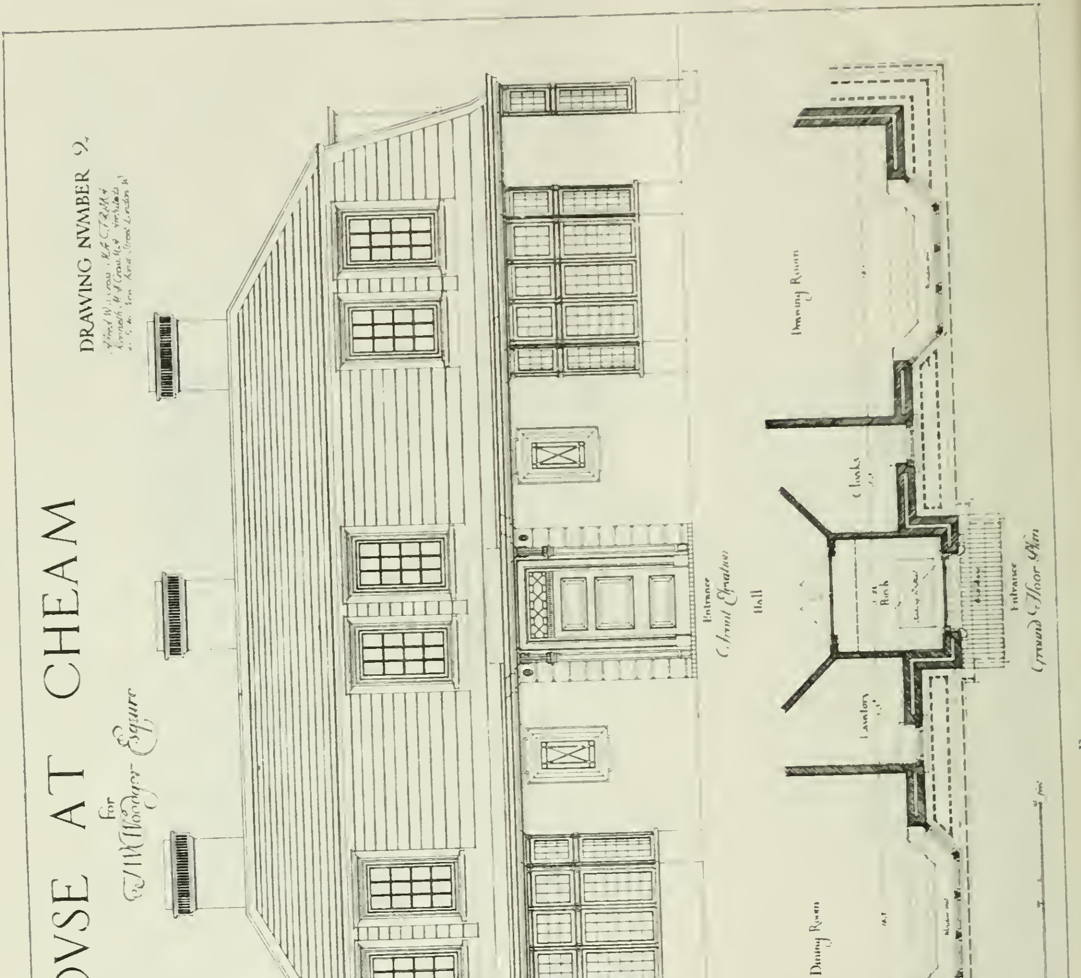

HOVSE AT CHEAM
for
F. W. Woodger Esquire
DRAWING NVMBER 2
DETAIL ELEVATION
Front Elevation
Entrance
Hall
Section
Bedroom
Hall
Porch
Ground Floor Plan
Drawing Room
Cloaks
Lavatory
Dining Room
Entrance
Entrance Gate

FIG. 4.

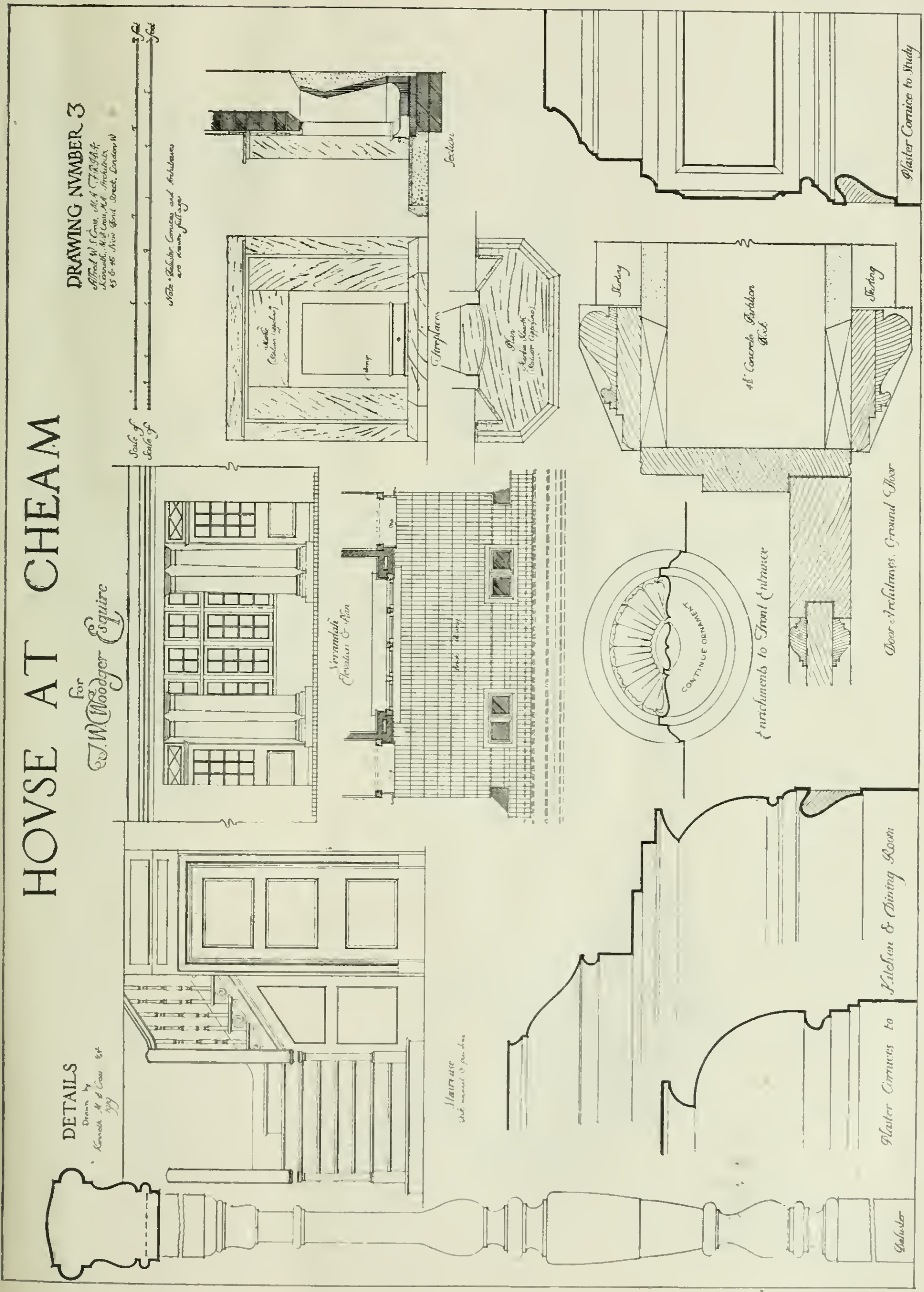
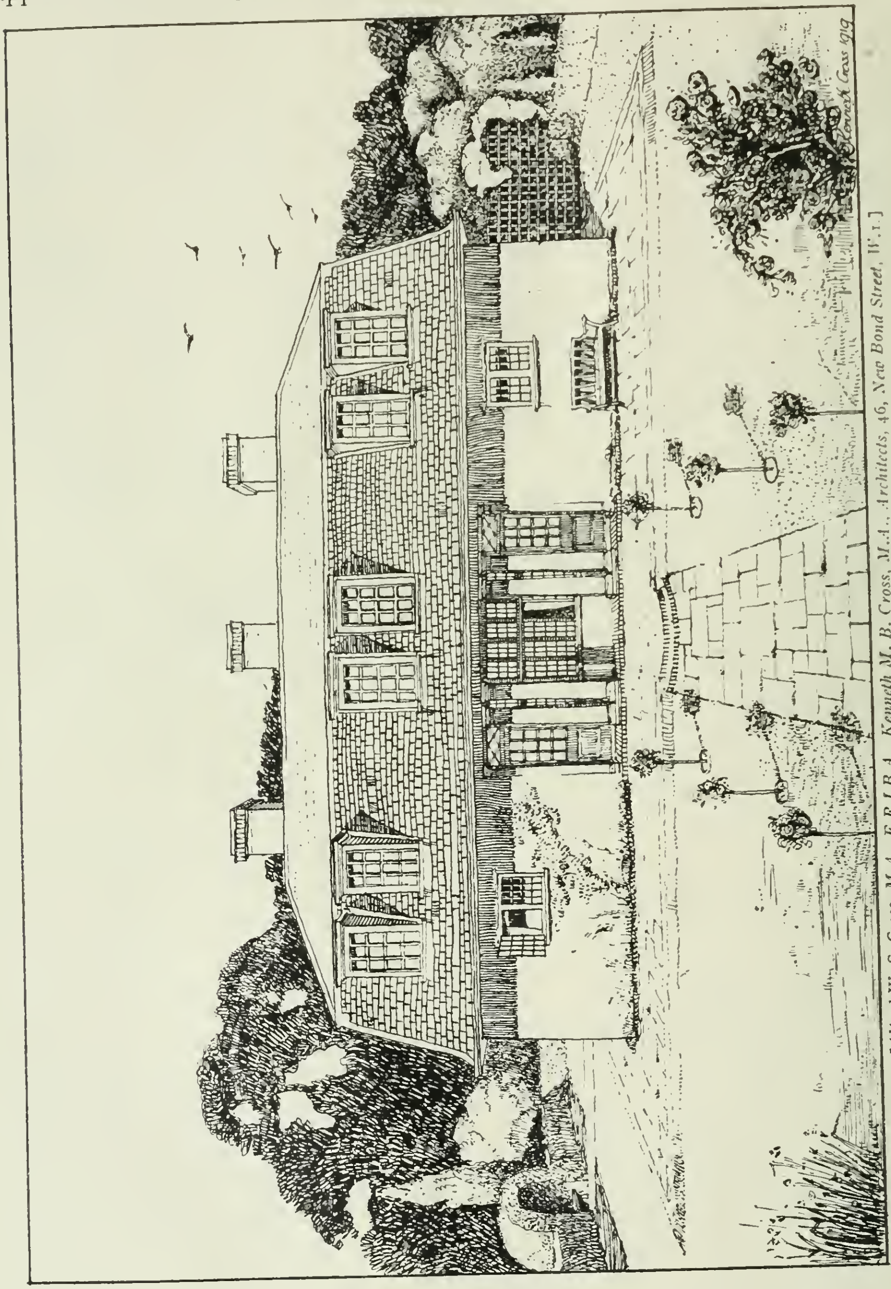

HOVSE AT CHEAM
For T. W. Woodger Esquire
DRAWING NVMBER 3
Alfred W S Cross, M.A. F.R.I.B.A.
Kenneth M B Cross, M.A. Architects
45 & 46 New Bond Street, London W
Note · Baluster, Cornices and Architraves are drawn full size
Scale of feet
Scale of feet
DETAILS
Drawn by Kenneth M B Cross
Staircase
Verandah Elevation & Plan
Fireplace
Marble
Plan
Section
Enrichments to Front Entrance
CONTINUE ORNAMENT
4" Concrete Partition
Skirting
Skirting
Door Architraves, Ground Floor
Plaster Cornice to Study
Plaster Cornices to Kitchen & Dining Room
Baluster

FIG. 5.

dormer window into pairs produces a delightfully rhythmic effect which is best apprehended in the perspective sketch. The fluting *motif* is also used on the



[*Alfred W. S. Cross, M.A., F.R.I.B.A., Kenneth M. B. Cross, M.A., Architects, 46, New Bond Street, W.1.*]

FIG. 6.

House at Cheam: view from Garden.

gate piers, carried out likewise in concrete. The outside surface of the walls and chimney stacks are cement rendered to a thickness of $\frac{1}{2}$ in.

A close study of this building will show that, although it entails the employment of a comparatively new material, a material whose full potentialities are by no means realised, it is not necessary to sever connection with the past in order to produce a design which shall possess intimacy with the material. Indeed such a course would be an error. When designing in brick, or stone, or any age-long recognised material the weight of tradition is heavy. The past, with its associations and experiences, makes itself felt by any one who has studied the art of architecture with assiduity, and who has in so doing related its products to the period of their production. The designer in concrete is certainly less hampered by such inarticulate influences, so that, while yet seeking guidance from the past, he feels himself free to adapt his design so as best to meet the requirements of a new material. His problem is to utilise this in a workmanlike and economical manner while still preserving a broad vernacular tradition, and remembering that an appreciation of form and indeed of beauty is to some extent dependent upon familiarity. Architecture is more communistic than the other arts, and the personal aspect should never be allowed to obscure this more comprehensive outlook. Unrestrained personal desires and ambitions must end in architectural chaos and the consequent loss of national architecture.

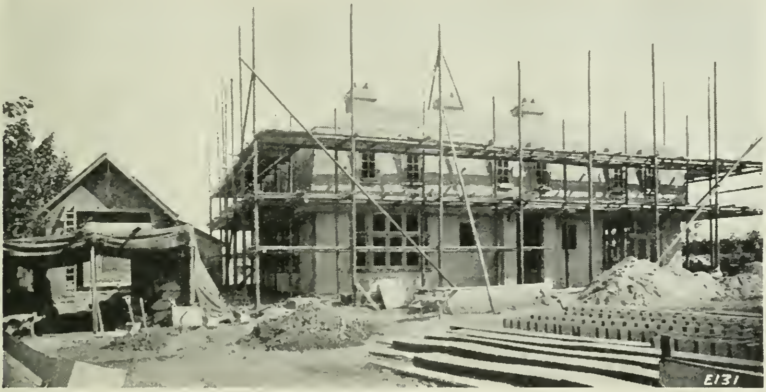


Fig. 7. A View from the Front during Erection.

It is in domestic architecture that the vernacular traditions are most potent in England. The history of the nation can be less clearly discerned in its public buildings, and the great traditions of church building have long since been lost in the devious paths along which designers have wandered owing to the growth of their self-consciousness. With the advent of reinforced concrete as a material for house construction a new situation arises, for out of the old traditions a new one is to be built up to meet the particular requirements, and a great responsibility rests with those engaged on such pioneer work. The house at Cheam seems to meet the new situation in the happiest manner. With its roots in the past it yet thrusts forward new shoots full of promise for a virile future growth. Moreover, it proves indisputably the suitability of concrete for this new purpose.

The architects are Messrs. A. W. S. Cross, M.A., F.R.I.B.A., and Kenneth M. B. Cross, B.A. The consulting Engineer was Mr. H. Kempton Dyson. The builders were Messrs. W. H. Lascelles, of Croydon.

THE GENERAL THEORY OF MOVING LOADS.

By V. A. BAILEY, M.A., Oxford.

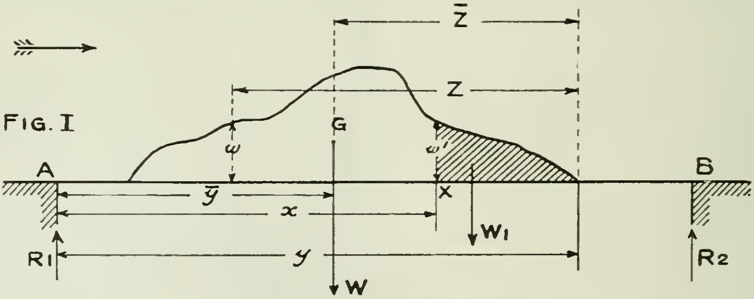
THE usual treatment of moving loads as given by text-books is somewhat heavy, and the results for the different cases considered seem to have no relationship to each other. From the student's point of view this involves an extra strain on the memory, while, on general grounds, it is always desirable to co-ordinate as many things as possible and to include all special rules in one general statement or law.

We will examine the general case of a moving load of any distribution crossing a one-span girder. Three rules will be deduced which enable us to determine the positions of the load which produce maxima and minima values of the Shearing Force and Bending Moment at any given section of the girder. These rules will be proved for a restricted case first, and then extended to the quite general case. This procedure is not really necessary, but makes the theory easier to follow.

Let us then consider the case of a load of any distribution, but restricted to remaining entirely on the span.

I. *Load shorter than the span.*

FIG. I



$$W_1 = \int_0^{y-x} w\,dz$$

Let X be the given section for which it is required to find the maxima and minima values of the S.F. and B.M. as the load moves along the span from left to right.

Let W =total load on the span.

W_1=the load to the right of X.

l =length of the span.

The other quantities used are shown in the diagram.

As the load moves all the quantities will change, except l, x, $\bar{z}$ and W.

Now $R_2 = \frac{W\bar{y}}{l}$, and hence if $y < x$ (*i.e.*, all the load to the left of X) then

Shearing Force $F = R_2 = \frac{W}{l}(y - \bar{z})$ and

Bending Moment $M = -(l - x)\ R_2 = -\frac{W(l-x)}{l}(y - \bar{z})$

both of which increase in magnitude with y.

We thus see that if the load is completely to the left, or completely to the right, then the S.F. and B.M. at X can be increased by moving the load up to X.

We thus obtain our *First Rule* :—

X cannot lie outside the range of the load when maxima and minima values of F and M occur.

We now require to find the positions of X within the load range which produce maxima and minima values of F and M.

We have :—

$$F = \frac{W\bar{y}}{l} - \int_0^{y-x} w\,dz \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$M = -\frac{W(l-x)}{l}\bar{y} + \int_0^{y-x} w(y-x-z)\,dz \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

F is a max. or min. when $\frac{dF}{dy} = 0$, *i.e.*, when

$$\frac{W}{l}\frac{d\bar{y}}{dy} = \frac{d}{dy}\int_0^{y-x} w\,dz.$$

= Rate of change with y of the hatched area in *Fig.* 1.

$= w^1$.

But $\bar{y} = y -$ (a constant) from the figure

$\therefore\ \frac{d\bar{y}}{dy} = 1$. Our condition then becomes $\frac{W}{l} = w^1$

We thus have our *Second Rule* :—

F is a max. or min. when the value of w at X equals the mean load per unit length of span.

From (2) we get that M is a maximum or minimum when :—

$$\frac{W(l-x)}{l}\frac{d\bar{y}}{dy} = \frac{d}{dy}\int_0^{y-x} w(y-x-z)\,dz$$

From page 195 in the third edition of Todhunter's Integral Calculus we find that the R.H. side of this equation $= \int_0^{y-x} w\,dz + o - o = W_1$.

Or more simply $\frac{d}{dy}\int_0^{y-x} w(y-x-z)\,dz =$ Rate of change with y, of the moment about X of the hatched area, which latter is, without much difficulty, seen to be equal to W_1.

Hence the condition is

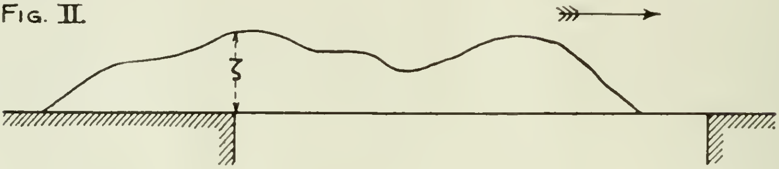
$$\frac{W}{l}=\frac{W_1}{l-x}=\frac{W-W_1}{x}\text{, giving our \textit{Third Rule}:—}$$

M is a max. or min. when the mean load per unit length of AX (or BX) equals the mean load per unit length of the whole span.

We are now in a position to generalise the preceding results, to cover all cases of moving loads on a Single Span.

Let the load be partly on and partly off the span as shown in *Fig.* 2.

Fig. II.



Let W be the total load on the span.

The rest of the notation is the same as before. We must now regard $\bar{z}$ and W as *not* remaining constant while the load moves.

For a movement dy we have $dW=\zeta dy$.

Also, by moments about the right end of the load $d(W\bar{z})=y(\zeta dy)$

$$\text{Hence } \frac{dW}{dy}=\zeta \text{ and } \frac{d(W\bar{z})}{dy}=y\zeta$$

$$\begin{aligned}\therefore \frac{d}{dy}(W\bar{y})&=\frac{d}{dy}(Wy-W\bar{z})=W+y\frac{dW}{dy}-\frac{d}{dy}(W\bar{z})\\&=W+y\zeta-y\zeta\\&=W\end{aligned}$$

[This result can also be obtained by considering the effect on R_2 of moving the load a distance dy.]

Differentiating equations (1) and (2) with respect to y will now give us exactly the same conditions for maxima and minima as before. Hence the three rules hold universally.

Mr. A. M. Maddox has pointed out to the author that the third rule may be deduced from an identical Rule given in Morley's *Theory of Structures* but proved only for a series of concentrated loads.

The general case may be regarded as an infinite series of concentrated loads, and thus the same rule is applicable to it.

We will now examine some particular types of moving loads in the light of our Three Rules.

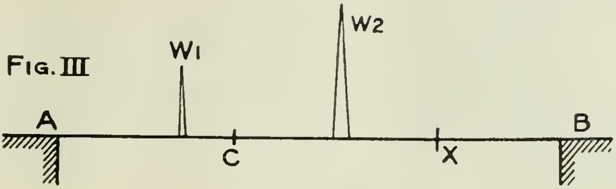
I. *Single Concentrated Load.*

The appropriate graphic representation of such a load is a very tall isosceles triangle with an extremely narrow base. The common representations by means of circles plainly cannot be regarded as w-diagrams.

The First Rule tells us straight away that the load must be over the given section in order to produce max. and min. values of F and M.

II. *Two Concentrated Loads.*

FIG. III



Let C be the section in AB for which $\frac{W_1}{AC}=\frac{W_2}{CB}$. The Second Rule tells us that F is a max. or min. when $\frac{W_1+W_2}{l}=w^1$ at X. Our mode of representation makes it clear that this occurs only when W_1 and W_2 are each over X.

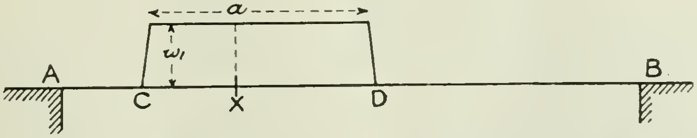
The condition that M be a max. or min. at X is that $\frac{W_A+W_B}{l}=\frac{W_A}{AX}=\frac{W_B}{XB}$ where W_A and W_B are the loads on AX and XB respectively.

$$\therefore \frac{W_B}{XB}=\frac{W_1+W_2}{l}=\frac{W_2}{CB}$$

Hence if X is to the right of C then $XB<CB$, i.e. $W_B<W_2$. Thus, for sections to the right of C, W_2 must be over the section to give the maximum value of M there. For sections to the left of C, similarly W_1 must be over the section. At C, either W_1 or W_2 will do.

III. *Short Uniform Load.*

The appropriate graphical representation for a uniform load is a rectangle. It is convenient to think of the ends of this rectangle as very slightly sloping out from top to bottom.



We have $W=aw_1$. Max. and min. F occurs when $w^1=\frac{W}{l}=\frac{w_1a}{l}$

i.e. when w^1 lies somewhere between w_1 and o.

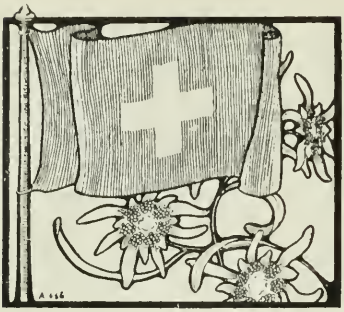
This plainly can only occur when the (sloping) ends are over the given section.

Max. M occurs when $\frac{W_A}{AX}=\frac{W_B}{BX}$

i.e. when $\frac{CX}{AX}=\frac{DX}{BX}$

The case of a uniform load longer than the span is also easily treated on these lines.

(*The author proposes giving the graphical constructions based on these Rules in a second article.*—Ed.)



TWO RECENT REINFORCED CONCRETE BUILDINGS IN SOUTH AMERICA.

THE ANGLO SOUTH AMERICAN BANK LTD., VALPARAISO.

THE building at present occupied by the Valparaiso Branch of the Anglo-South-American Bank, Ltd., was recently erected, to replace an old building destroyed by fire. The new building has been leased to the Bank as temporary premises, during the reconstruction of the Bank's own property in the same street (Calle Prat) which is now in full swing, and will be one of the most modern and perfect buildings in South America. We shall have the pleasure of giving our readers interesting details of this scheme when farther advanced.

The building is of considerable extent, running through from one street to

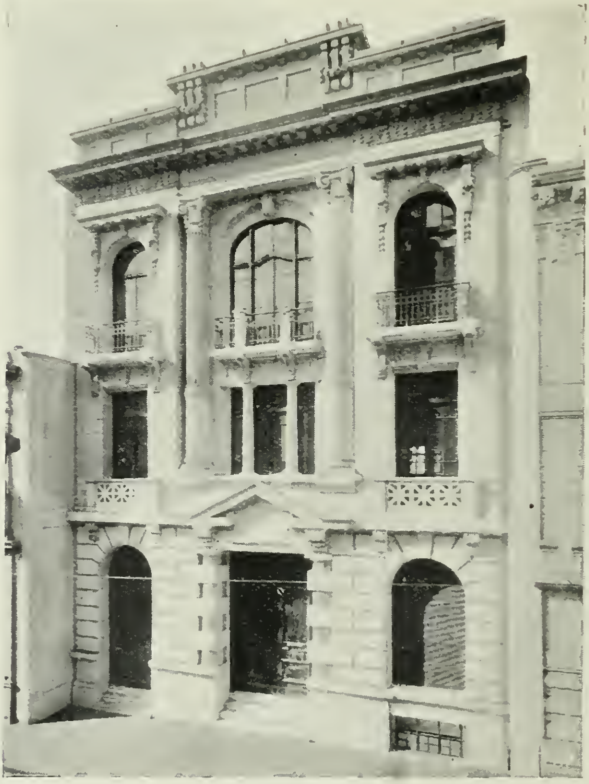


FIG. I. TEMPORARY PREMISES FOR THE ANGLO SOUTH AMERICAN BANK, LTD., VALPARAISO.

the other, occupying an area of upwards of 4,000 ft. The main entrance is in the Calle Prat; the frontage to the Calle Cochrane being a story lower. This basement floor contains the very supersafe strong-rooms built by the Bank, of extra heavy concrete, reinforced with a steel network of $\frac{3}{4}$ in. bars.

The building was designed and erected by Mr. Robert Parker, Architect of Valparaiso, for the owner, Mr. Juan Brown. The façade is finished with white cement, in imitation of white dressed stone. All woodwork is of "lingue" (a very popular native lumber resembling birch), French polished in natural colour.

The building at present under consideration is constructed almost entirely of reinforced concrete, the floors being reinforced with B.R.C. fabric; the roof, however, is timber framed.

NEW PREMISES OF THE CHILE TELEPHONE COMPANY LTD., VALPARAISO.

These premises have been erected to receive the modern automatic plant which has been recently introduced into the Company's local service, and occupy a site a few hundred yards from the original central offices, which suffered very considerably during the terrible earthquake of 1906. As the new site is situated within the principal danger zone of this catastrophe, it was recognised that the only safe building system was reinforced concrete.

The work of designing and carrying out the erection of a suitable building was entrusted to the local architects and engineers of the firm of Frederick Sage & Co. Ltd. (London and Valparaiso).

As this neighbourhood was originally reclaimed from the sea and has been made up from time to time, a solid foundation was unobtainable. While excavating for preliminary investigation, three distinct levels of street paving were brought to light, about a yard apart. With a view to obtaining a safe base, a reinforced concrete raft foundation was constructed, upon a complete system of concrete piles.

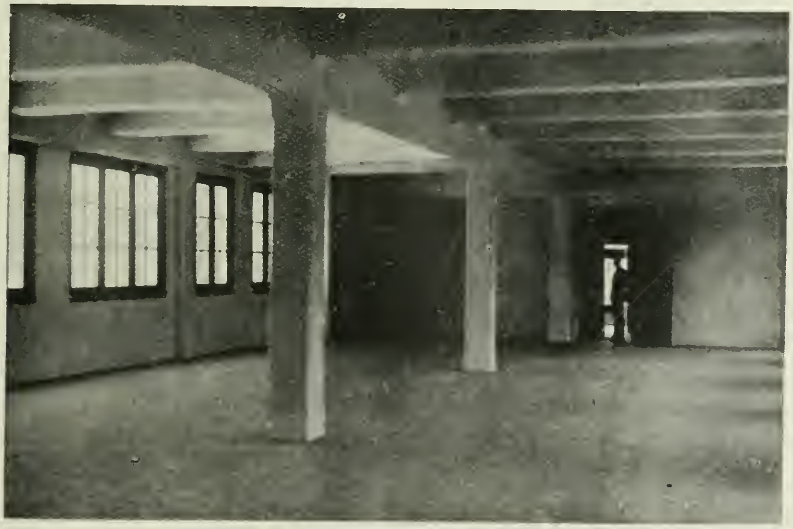


Fig. 2. Building for the Chile Telephone Co., Ltd. First Floor.

The building is of reinforced concrete throughout, all floors being reinforced with B.R.C. fabric, as also the foundation and roof.

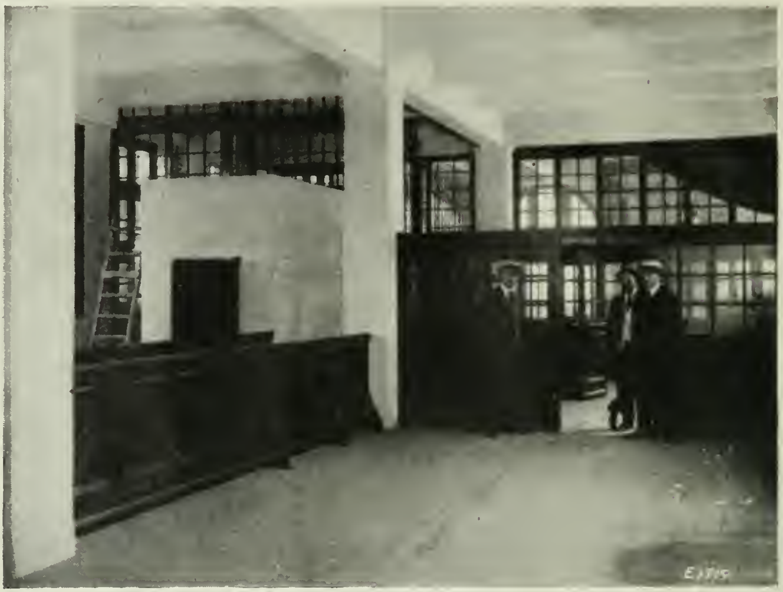


Fig. 3. Valparaiso Office.

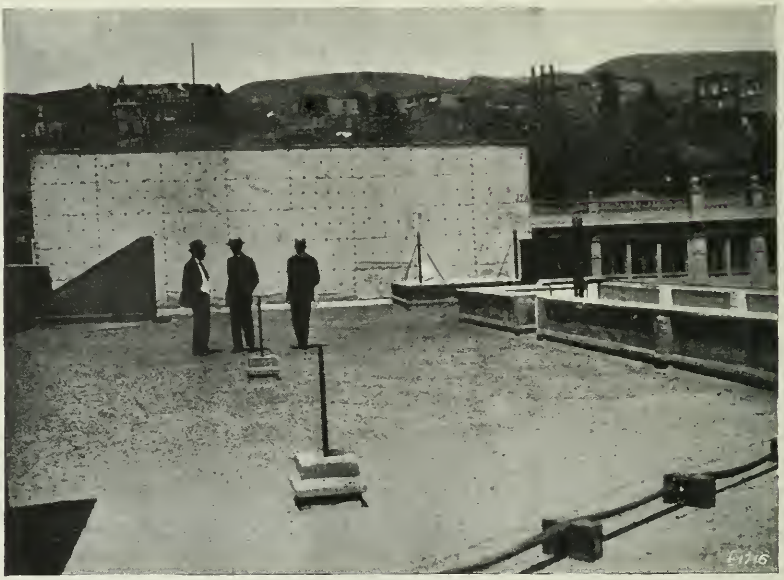


Fig. 4. Showing Roof.

The roof is practically flat, with the exception of a slight camber in the centre, and is covered with a bituminous composition and roofing felt.

Notwithstanding the incombustible nature of the building, special measures have been adopted for assuring the safety of the employés in case of fire, by the erection of an iron exterior-emergency-stairs.

A reinforced concrete tunnel is constructed underneath the building to contain the cables for the new system of subterranean telephone lines.

The interior of the building is simple in construction but effective and is finished off in soft agreeable tones.

The exterior is finished in white cement, tooled when set, in imitation of dressed stone.

This is one of the first buildings in this country constructed of purely reinforced concrete, without the aid of steel joists or beams.

We are indebted to Mr. George Mallet for our particulars and illustrations.

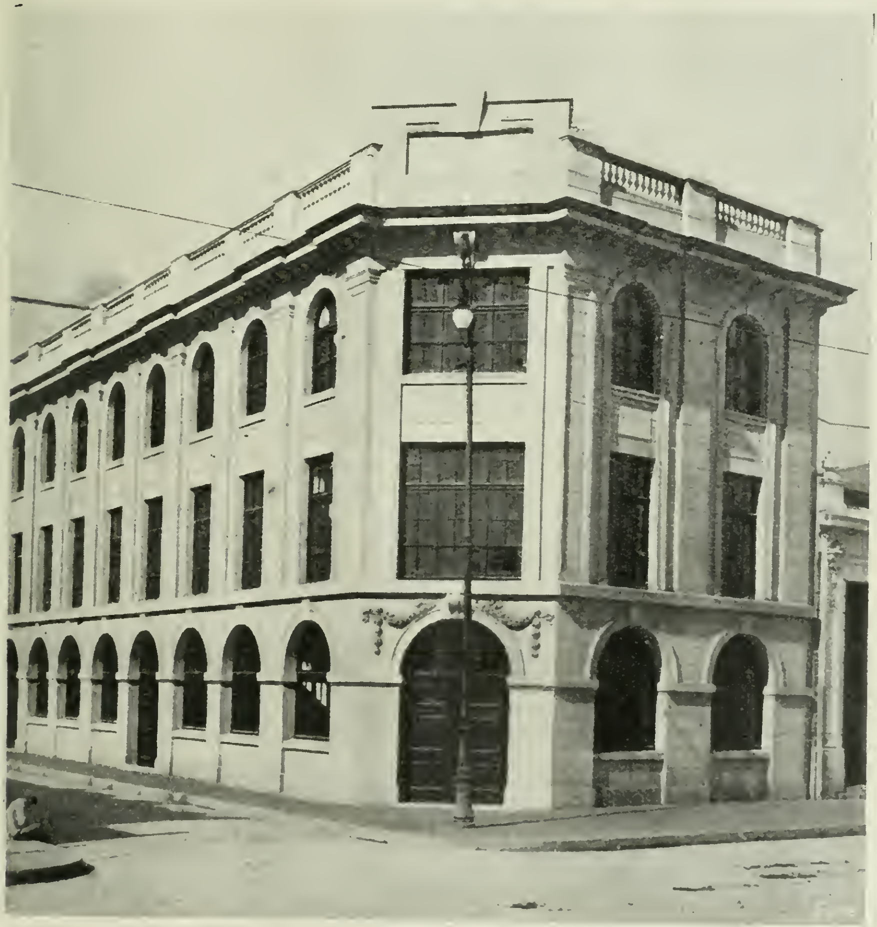


FIG. 5. GENERAL VIEW. BUILDING FOR THE CHILE TELEPHONE CO., LTD.

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY

RECENT ELECTIONS INTO THE INSTITUTE.

Members : BUTTERFIELD, Ernest.
CLARKE, Ernest Mortimer.
HANAUER, Herbert William.
NEWBORN, Charles Reginald.
PAYNE, Crompton Spencer.
SMITH, George Willie.
SMITH, William Herbert.
TOMES, Francis William.
YEARSLEY, Herbert Aloysius.
Associate :— JACKSON, Charles Albert.
Associate-Members :— BORER, Oscar.
PHILLIPS, Edward Hyde Benjamin.
ROGERS, Albert William (from Student).
STEVENS, Donald Arthur (from Student).
TATE, Newman.

CONCRETE AGGREGATES *(Continued)*.

(39) **Gloucester :—**

General description : Clean sharp sand and gravel.
Source and locality of same : Gravel pits, Barnwood (2 miles from Gloucester).
How obtained : Open digging.
From whom obtained : Messrs. Chambers and Company.
Is available quantity limited ? Unlimited.
Present maximum output per day : 200 tons (could be increased).
Transport facilities : Road.
Is there any provision at or near source for washing or crushing ? Washing unnecessary—no crusher.
Price per cub. yd., and where delivered : 7s., delivered Gloucester.
Kind of stone or coarse material : Limestone gravel.
Kind of sand or fine material : Limestone gravel.
Relative proportions of coarse and fine materials : Half and half.
Shape of particles : Angular.
Approximate percentage needing crushing to pass ¾ in. screen : 10 per cent.
Impurities present : None.
General remarks : Good for concrete.

(39*a*) The Manager of the Tytherington Stone Company at Falfield, Gloucestershire, writes that their quarries, situated on the Midland Railway, furnish unlimited supplies of broken stone and chippings, suitable for concrete; there are no facilities for washing the material. Some thousands of tons of material for concrete were supplied to the National Shipyards, Chepstow.

(40) **Gorleston** :—Beach shingle and sand, containing 10 per cent. mud; needs washing. (R.C.B.)*

(41) **Halifax** :—There is some excellent stone. On the other hand, there is some soft sandstone, which is too weak for concrete. (R.C.B.)

(42) **Harlow** :—Coarse sand (with 12 per cent. loam) and fine sand (with 4 per cent. loam), both kinds containing chalk. (R.C.B.)

(43) **Herefordshire** :—

General description : Gravel pit.
Source and locality of same : Stoke Prior.
How obtained : Raised by hand.
From whom obtained : J. H. Davis, Leominster.
Is available quantity limited ? No.
Present maximum output per day : None (*sic*).
Transport facilities : Horse-drawn vehicles only.
Is there any provision at or near source for washing or crushing ? No.
Price per cub. yd., and where delivered : 3s., on site.
Is composition uniform ? Yes.
Kind of stone or coarse material : Red sandstone.
Kind of sand or fine material : Sharp.
Relative proportions of coarse and fine material : 3 rough to 1 fine.
Shape of particles : Rounded.
Size of particles : ½ in. to 3 in.
Approximate percentage needing crushing to pass ¾ in. screen : 50 per cent.
Impurities present : Small amount of clay.
Source of information : Mr. V. Godfrey, of Stoke Prior, the proprietor.
Weight per cub. ft. dry : About 1 ton.

* See previous issues for index letters.

SOME METHODS OF SECURING IMPERMEABILITY IN CONCRETE.

By EWART S. ANDREWS, B.Sc. (Eng.).

The following is an abstract from a Paper read at the One Hundred and First Ordinary General Meeting of the Concrete Institute. Mr. E. Fiander Etchells, President, was in the Chair.

In many of the uses to which concrete is put, it is either of primary or secondary importance that the concrete shall be impermeable to the passage of water and other fluids. In many other cases, such as marine structures, it may be regarded as of secondary importance, because deleterious results are caused by the chemical and physical action of liquids which find their way into the structure of the concrete.

In either case it is very desirable to avoid permeability.

Causes of Permeability Troubles.—These come under three main headings :—

(*a*) Caused by materials percolating through voids in the material.
(*b*) Caused by the existence of cracks right through the concrete.
(*c*) Caused by chemical action of materials upon the concrete even when there are no voids or cracks.

Secondary actions often give rise to trouble under (*a*) and (*b*), due to chemical or physical action of liquids which find their way into the pores of the concrete.

Common Methods of avoiding Permeability.—These we may classify as follows, leaving out of consideration for the present the question of cracks in the concrete :—

(A) Void-filling methods.
  (1) Preventing voids by dense concrete.
  (2) Integral preparations.
    (*a*) Materials added in making concrete.
    (*b*) Modified cements.
(B) Coating methods.

(A). **Preventing Voids by Dense Concrete.**—There is no doubt that one of the best ways to make concrete impermeable is to grade and mix it properly. Careful experiments have shown that concrete can be made waterproof without the addition of water-proofing compounds. This applies particularly to the case in which, as in reinforced concrete, for purposes of strength it is desirable to employ a concrete comparatively rich in cement.

Instead of employing comparatively expensive materials to fill up the holes in the concrete we should endeavour to prevent the production of such holes.

If the concrete is too dry there will not be sufficient water to ensure the complete hydration of the cement and air is likely to be retained between the particles, resulting in a spongy concrete ; if it be too wet then the excess water will ultimately dry out and will leave voids.

Studies of Concrete by aid of the Microscope.—Very interesting and valuable data upon the consistency of concrete have been obtained by the use of the microscope by Mr. Nathan C. Johnson, who has expressed his views clearly if strongly in papers which will be found in *Concrete and Constructional Engineering*, June-December, 1915.

Mr. Johnson pays considerable attention to the unhydrated cement to be detected in micro-photographs of concrete, and this question of unhydrated cement is of great importance in the problem of permeability which we are now considering. Briefly, he states that not more than 20 per cent. of the cement in concrete is hydrated and that the remaining cement merely acts as an inert space-filler ; he attributes this small amount of hydration to the high surface tension of the water and suggests that small quantities of substances such as alcohol, ether, sodium oleate, sodium hydroxide, etc., reduce the surface tension of the water and increase the hydration of the cement, thus increasing the strength and impermeability of the concrete.

" Integral " Preparations for preventing Permeability. (*a*) **Materials added in mixing the Concrete.**—The method of reducing permeability of concrete by means of the " integral " system consists in the use of certain materials which are added to the concrete when it is being mixed ; the action of some of these materials may be described as inert, their function being merely to fill up the voids in the concrete. Others, commonly of the soap family, have a chemical action upon the cement ; while others are claimed to have a kind of catalytic action in promoting the formation of colloids which increase the hydration of the cement.

Hydrated Lime.—Hydrated lime is a finely divided white powder made from ordinary lime by the addition of just sufficient water to ensure complete slaking, so that the heat generated evaporates all the excess water and leaves the product dry.

Experience has shown us that the addition of hydrated lime causes the resulting concrete to be more dense and uniform ; the amounts recommended as the result of experiments by Mr. Sandford Thompson* are as follows :—

Portland Cement.	Sand.	Stone.	Hydrated Lime (% weight of cement)
1	2	4	8
1	2·5	4·5	12
1	3	5	16

In the report of the United States Bureau of Standards, it is stated that the value of hydrated lime as a waterproofing medium is due to its void-filling properties only and that similar results could be expected from any other finely ground inert material ; but the author believes that the effect of the lime in providing what practical men would call a " fatter " mixture is one of considerable value which most other inert materials would not possess.

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* American Society of Testing Materials, 1908.

Other Inert Fillers.—A very large number of finely ground inert materials have been found to decrease the permeability of concrete ; mention may be made of felspar, clay, sand and Portland cement (ground finer than normal). Some authorities have held that clay has the effect of increasing the much-disputed colloid action in the cement.

In considering the use of these inert fillers we ought always to consider whether we should not obtain as good results by the use of a correspondingly increased quantity of cement.

Soap Compounds.—One of the oldest methods of waterproofing concrete was the Sylvester process which consists in applying coats of soap and alum.

Other chemically similar methods consist in the addition of materials which will cause the formation of the insoluble calcium stearate in the pores of the concrete. Some of the best known preparations on the market are of this kind ; they often consist of powders made from lime, fat and an alkaline carbonate.

There appears to be evidence that the void-filling materials of the soap type are liable to become ineffective in the course of time, due to the presence of various impurities in the water or to the nature of the other fluid retained in the vessel which slowly dissolves out the aluminium or calcium stearate, thus leaving the concrete probably more porous than it would have been had the material not been added.

Metallic Powders.—Many waterproofing and concrete-hardening preparations have been employed consisting of powdered pig iron or iron filings which oxidize and expand, thus filling the voids in the concrete. Small quantities of sal-ammoniac or flowers of sulphur are often added to assist in the oxidation of the iron.

Silicates.—Sodium silicates (water glass) and potassium silicate, both of which are soluble in water, have been employed for increasing the impermeability of concrete. The function of these silicates is to form with the lime of the cement a calcium silicate ; but some chemists state that the amount of lime in the cement is insufficient for such action.

(*b*) **Special Cements.**—A number of proprietary brands of cement have appeared from time to time in which various materials have been mixed with Portland cement clinker and ground up with it with the intention of increasing the impermeability of the cement.

The cement of this type which is probably the best known to British engineers is that made in accordance with British Patent Specification No. 13542/14 (Goddard) ; in this cement the gypsum is treated with a small quantity of tannic acid.

From the tests of this material the author has seen and from the results of other tests substantiated by independent testing engineers, he is satisfied that this cement has less permeability than the standard cement. In one test which the author witnessed, a thickness of $\frac{7}{8}$ in. of a concrete made of 1 part of the cement and 5 parts of crushed limestone successfully resisted a water pressure of 200 lb. per sq. inch.

(B). **Coating Methods of securing Impermeability.**—Many of the materials already referred to under integral compounds form the basis of methods of coating concrete with a view to preventing access of fluids into the structure of the concrete. In dealing with these coating methods we can consider two types of coating materials—(*a*) those employed to prevent the materials used from attacking the concrete chemically, and (*b*) those employed to form a dense impervious layer to the concrete. The aim with the second class will be to penetrate into the surface of the concrete and with the first to form a resistant skin outside the concrete.

Sylvester Process.—This is the equivalent of the soap and alum process previously referred to.

Good results have been obtained with a solution of 2 ounces of alum per gallon of hot water and a solution of 12 ounces of Castile soap per gallon of hot water. The alum solution is applied first and worked in with a stiff brush and is immediately followed by the hot soap solution. The temperature of each wash should be kept at above 100° F.

Paraffin (Wax) Process.—Many cases are recorded of successful coating to avoid permeability difficulties by means of the paraffin process. The paraffin may be dissolved in a high volatile compound to enable cold application ; the liquid is rubbed thoroughly into the surface with a stiff brush, three coatings being desirable when the surface is rough. A solution of one part paraffin wax with two parts kerosene (paraffin oil) may be used. Some authorities recommend driving the material into the concrete by means of a blow lamp.

Bituminous Compounds.—This class includes a large number of coating materials such as asphalt. Such methods of coating are comparatively expensive in practice and the materials require care in their selection to ensure that the coating shall retain the elasticity which is essential for the proper functioning of the material and yet shall not " run " at high temperatures. The liability of the coating to come away from the concrete also has to be considered.

Special Chemical " Paints."—A number of special chemical covering materials or paints have been devised with a view to resisting the action of special liquids under various temperature conditions.

A coating preparation devised to provide an oilproofing material for tanks is patented in British specification No. 149365 (Ivinson and Roberts) ; it comprises 30–65 parts by weight of chloride of zinc, 30–55 parts of oxide of zinc, and 2–20 parts of chloride of ammonia.

Tests have been made by the National Physical Laboratory upon model reinforced concrete tanks coated in accordance with this process. The thickness of concrete was 3 in. and the internal dimensions gave a cube of 6 in. side. Tests were made up to pressures of 50 lb. per square inch with petrol, with petrol and paraffin in equal proportions, linseed oil and turpentine in equal proportions, and with water. In no case was there evidence of permeability.

Contraction Joints.—The cause of leakage in concrete structures may be due to the development of actual cracks in the concrete and no amount of doctoring the concrete can remedy the trouble caused by cracks.

Although it is true that many such cracks can be attributed to failure on the part of the designer to provide adequate reinforcement to carry tensile stresses, the principal cause of this difficulty is the contraction of the concrete in setting. On large structures it appears to be practically impossible to avoid such cracks, and the wisest plan is to induce them at specified places by the adoption of contraction joints—often referred to as expansion joints.

American Bureau of Standards Investigation.—The subject of permeability of concrete has been experimentally investigated at length by the United States Bureau of Standards and a full report will be found in Technologic Paper No. 3, by Messrs. R. J. Wig and P. H. Bates. In these experiments a number of proprietary preparations were taken and test specimens were tested ; the summary of the report appears to the author to be so important that he has reproduced it *in extenso* as follows :—

" Portland cement mortar and concrete can be made practically watertight or impermeable as defined below to any hydrostatic head, up to 40 feet without the use of any of the so-called ' integral ' waterproofing materials, but in order to obtain such impermeable mortar or concrete considerable care should be exercised in selecting good materials as aggregate, and proportioning them in such a manner as to obtain the dense mixture. The consistency of the mixture should be wet enough so that it can be puddled, the particles flowing into position without tamping. The mixture should be well spaded against the forms when placed, so as to avoid the formation of pockets on the surface.

" The addition of so-called ' integral ' waterproofing compounds will not compensate for lean mixtures nor for poor materials, nor for poor workmanship in the fabrication of the concrete. Since in practice the inert integral compounds (acting simply as void-filling material) are added in such small quantities, they have very little or no effect on the permeability of the concrete. If the same care be taken in making the concrete impermeable without the addition of waterproofing materials as is ordinarily taken when waterproofing materials are added, an impermeable concrete can be obtained.

" The terms ' permeability,' ' absorption ' and ' damp-proof ' should not be confused. A mortar or concrete is impermeable (though necessarily damp-proof) as defined and used throughout this report, when it does not permit the passage or flow of water through its pores or voids.

" The absorption of a mortar or concrete is the property of drawing in or engrossing water into its pores or voids by capillary action or otherwise. If the pores or voids between the grains or particles in the individual grains are sufficiently large and connected from surface to surface of the wall, the concrete will be permeable to water. If the pores or voids are very minute, but connect one with another, theoretically, they may act as capillary tubes, absorbing or drawing in and filling themselves with water; but capillary forces will tend to hold the water in the pores and will prevent the passage or flow of water even though one surface of the wall may be exposed to considerable hydrostatic pressure. For all practical purposes a wall under such conditions would be considered perfectly watertight and impermeable, although it may be highly absorptive. If these minute pores do act as capillary tubes and are never minute enough to prevent capillary action, the moisture either as water or water vapour would in time penetrate entirely through and fill a concrete wall, no matter what the thickness or composition. In such a case the capillary forces would not permit an actual flow of water, but these forces may carry moisture, entirely filling the wall and, unless evaporation is retarded, the opposite face of the wall would appear dry. In such a case the concrete would be considered impermeable but not damp-proof.

"The damp-proofing tests as conducted would indicate that Portland cement mortars can be made not only impermeable but damp-proof as well, as defined above, without the use of any damp-proofing compound. However, these tests should be interpreted with caution as the evaporation may have been sufficient to care for the slight amount of moisture coming through the test pieces without indicating on the filter paper. Thus it cannot be stated that if a material were used which was damp-proof according to this test if used as a basement wall, one surface being constantly exposed to moisture and the other surface in an inclosed room where there would be little or no circulation of air, that the interior surface would not appear damp and the atmosphere become saturated with moisture. The tests of coating materials as damp-proofing mediums can be considered as only preliminary, but the results, considered along with the chemical discussion, throw some light on their comparative merits. The mortar used in these tests was perhaps too coarse and too absorptive for a fair test, the purpose of the rough surface was to test the flowing qualities of the coating and it would seem that many of the failures may be due to the poor or imperfect spreading and adhesive quality. Several of the compounds deteriorated and proved their unfitness for the purpose intended.

"Well-graded sands containing considerable graded fine material are preferable for making impermeable concrete, but if such is not to be had, fine material in the form of hydrated lime, finely ground clay, or an additional quantity of cement will be found of value.

"Where Portland cement mortar is used as a plaster coat, if sufficient cement be used and the sand contains sufficient fine material (or fine material be added) and the mortar be placed without joints and well trowelled (care being taken not to over-trowel, which may cause crazing), the coating will be effective as an impermeable medium without the use of any waterproofing compound.

"As a precaution under certain conditions, it is undoubtedly desirable to use bituminous or similar coatings, even on new work, as protection where cracks may occur, due to settling of foundation or expansion and contraction caused by temperature changes. In large or exposed work it is practically impossible to prevent cracks, but where cracks can be prevented no coating whatever is required to make the structure impermeable.

"The permeability of Portland cement mortars and concretes rapidly decreases with age.

"None of the integral compounds tested reduced the absorption of the mortars before they were dried by heating at 212° F. Thus they would have little or no practical value. But some of the so-called integral waterproofing compounds did decrease the absorption obtained after drying the mortars at 212° F., and the rate of absorption was much slower in these cases. The addition of hydrated lime and clays seemed to have little or no effect on the absorption.

"The addition of any of the compounds tested to a mortar in the quantities used in these tests does not seriously affect the compressive or tensile strength. The addition of the inert void fillers to mortars, as used in these tests up to 20 per cent. of the volume of cement, increases the compressive strength."

Some Conclusions and Suggestions.—One of the difficulties in coming to practical conclusions on this subject is that so many of the data are based upon tests made under laboratory conditions and we have to decide as to how far we are to be guided in practice by the results of these tests.

The trend of the evidence appears to be that if great care is taken in the grading, mixing and placing of the concrete, a voidless concrete can be obtained and that such concrete is as good as, if not better than, that obtained with the special preparations. Some of the advocates of these special preparations argue in their persuasive literature that in practice it is impossible to exercise the great care necessary for this result and that therefore some special treatment is necessary. Such statements are often supported by experimental test results made by engineers of unimpeachable standing and showing that an increased strength results from the use of the particular material. But the argument against laboratory conditions is a boomerang which may come back on the thrower. The test results obtained with special preparations are also made under laboratory conditions, and in the case of integral mixtures it may be assumed that the added materials will be more thoroughly mixed with the concrete than can be assumed to occur in practice ; if these materials are not uniformly mixed with the concrete in actual practice, as seems probable, it is at least doubtful if their effect will be as good as can be obtained in laboratory tests.

Tensile Strain.—This question of colloid action is of importance in relation to impermeability if, as some people suggest, it would result in a more plastic material less liable to cracking, but it appears to the author that this question of yield or plasticity can be investigated as a fact apart from the theory of colloids.

If the addition of certain materials to the concrete renders it more plastic, then a test specimen would show greater strain before fracture by tension than will occur without such material. The cause of cracking in concrete, which probably gives rise to much of the permeability troubles, is failure to contract without fracture. It is therefore suggested that the question should be tested by measuring the extension before fracture of tension specimens made from concrete treated by the various processes.

Standard Permeability Tests.—It is well known that permeability tests upon concrete made upon small specimens are likely to give more favourable results than one is likely to obtain with larger structures in practice and that microscopic cracks in the specimen may prevent percolation by water, whereas water would find its way through the correspondingly larger cracks in larger models. The author therefore suggests that in testing small specimens for permeability one should employ a liquid known to find its way more easily through the smallest voids, and he would suggest also that if any standard permeability test be devised, a liquid such as petrol should be employed for the purpose.

The Effect of Cost Consideration upon the problem of Impermeable Concrete.—Previous considerations have shown that with requisite care in grading, mixing and placing, it is possible to obtain a practically impermeable concrete. The author has no doubt from the large number of recorded experiences of engineers which he has studied, that in practice the addition of certain materials to the concrete gives better results than had previously been obtained under the ordinary practical conditions.

From the practical point of view, therefore, we have to decide whether it costs less to exert the meticulous care in grading and supervision than to add these special preparations. This will depend to some extent upon the nature of the structure and the strength of the concrete required to resist the forces acting upon it. In reinforced concrete structures we require a concrete of such strength that we must have the amount of cement which, with aggregate properly graded and mixed, will give us a practically impermeable concrete. In other cases such strength may not be called for, and it may prove cheaper to employ an inert void-filling material than to add more cement.

DISCUSSION,

Dr. J. S. Owens, F.G S., confined his remarks to a question which he thought did not receive sufficient attention, namely : surface tension. The term capillarity or capillary attraction is a familiar one, but the profound effect that this force had in everyday things, such as in concrete, was not generally realised. Assuming a porous concrete, in the sense that there were communicating channels through the body of the concrete, as there always were, then whether or no a liquid would penetrate those channels depends chiefly upon surface tension. If the surface tension of the liquid were greater than the surface tension of the solid it would penetrate ; if the reverse, it would not. If a small glass tube were dipped into water the water would rise inside the tube if the tube were small enough, and a film would be pulled up ; the surface tension is measured by the height of the column pulled up inside the tube by that film. A very familiar example of waterproofing which depends entirely on surface tension is the ordinary rainproof coating. The water refuses to wet the concrete because the tension of the material is greater than the tension of the water. Porosity is not the same as permeability; the channels might be there, but they might not be capable of allowing the flow of water through them. Also the channels might refuse to permit water but not other liquids to flow through them. Thus permeability has to be considered with reference to the liquid whose flow it is desired to prevent. Concrete might conceivably be impermeable to water and permeable to something else, a very important thing to keep in mind, because up till recently the permeability of concrete has only been considered with reference to water; but now that there are many concrete tanks built for holding oil, it is necessary that the concrete should be impermeable to oil. Coming to the paper, the author had suggested that the standard permeability test should be made with petrol. He (the speaker) was not disposed to agree to that as a matter of principle. He thought it possible to get something which was permeable to petrol and impermeable to water, or *vice versa*, under proper treatment.

Mr. H. J. Deane, B.E. (Sydney), M.C.I., referring to the necessity of avoiding materials which produced permeability, said that a good many of these materials contain SO_3, and for that reason he was particularly opposed to Fletton bricks in underground work, where it was always wet. He had been responsible for certain work constructed of Fletton bricks with cement mortar without any waterproof backing at all. The ground was supposed to be dry, but a thin film of water got through. The front of the brickwork was tiled over with glass tiles. After some time his inspector called his attention to a certain portion of the work which was showing signs of distress, and the next morning the whole of that portion had fallen down. It was ascertained that the water came through the brickwork, which was found to contain a very large proportion of sulphurous acid. That was the entire cause of this cement failing. As to the use of wax, the first use he had ever put it to was in connection with the building of some workmen's cottages with bricks which were not impervious to water, with the result that under the window sills, where they were subject to the driving action of the south-west winds, the water came through and made the houses practically uninhabitable. After a great deal of discussion he suggested that they should coat them with paraffin wax. They applied it hot, having first dried the bricks, and melted it in with a blow-lamp. It had proved entirely successful, and he applied the same thing to another building, which was constructed of very nice bricks, with a concrete roof. This had never been at all satisfactory previously, as the water came in in the rainy season, so they applied the same sort of process and produced results entirely satisfactory. Wax was a very good thing to apply in such cases. It would probably be a good thing to apply to reinforced concrete tanks. Where they had ample opportunity of using cement with proper hydration he was sure they would get all they wanted without the use of wax.

Mr. Gordon Boyd (Castor Waterproofing Co.) said that the *raison d'être* for waterproof compounds he thought they would find in the remark made by the author to the effect that, if they left concrete, or, for that matter, any sort of cement work, to the ordinary workman, he never did it well. With regard to Castor, he claimed that by its use the highest water pressure could be resisted with not more than ¾ in. thickness of rendering gauged 2 parts sand to 1 of cement. No matter how great the water pressure behind it, they were able to make an internal rendering hold to the surface because the chemical action of this material on cement increased its adhesion to the work. It was therefore possible to effect considerable economies by its use, when it was desired to overcome percolation or flooding of existing structures below level.

Mr. Frederick Coleman (The Adamite Co., Ltd.) said that ideal waterproofer must be liquid, and as regards waterproofing compounds, those who handled the compound had to be on the spot to see that the concrete used with the mixture was the proper kind of concrete. He then gave the substance of a letter from Colonel H. C. Boyden, of the Portland Cement Association, Chicago, written on December 30th, 1920, with regard to the strength of concrete as affected by the amount of mixing water. In America they were convinced, in regard to concrete roads, that the best concrete was made out of a very dry mix, whereas there was a disposition in England to deny that the strength of concrete was affected by the amount of the mixing water, and that concrete roads made of really liquid concrete gave the best service. Colonel Boyden said he believed without a doubt that the compressive strength and wearing ability of concrete was more dependent upon the ratio between the volume of the mixing water and the volume of the cement than upon any other factor entering into the making of concrete.

Mr. W. J. Bratt (Szerelmey, Ltd.) agreed with the author in that there were two methods of obtaining impermeability in concrete, i.e., by treatment of the surface of concrete after construction, and by incorporating a waterproofing medium with the aggregate at the time of mixing. The speaker's firm had adopted their present method of interposing a waterproof barrier between the source of the damp and the wall or other structure. He said Szerelmey Stone Liquid was purely mechanical in its action. The composition formed, in its successive coats, an impervious barrier a short distance within the stone or concrete. No discrimination need be used; it could be employed upon every kind of stone and concrete. Its period of effectiveness was practically unlimited, and it was claimed that by the prevention of the attrition by moisture and the consequent disintegration of the particles the surface of the stone or concrete was enabled to weather naturally and so present a case-hardened and waterproof face to all conditions. The liquid was transparent and could be used upon concrete or stone faces without altering their colour.

At this point the discussion was adjourned and was resumed on April 14th, Mr. E. Fiander Etchells, the President, being in the chair.

ADJOURNED DISCUSSION.

The President, in re-opening the discussion, said that among other things the question was one of relative cost. When dealing with concrete in large quantities it was necessary to decide whether it would be cheaper to instal screening, washing and grading machinery, and get an impermeable concrete in that way, or to take the crude gravel as it came from the ground and mix a waterproofing compound with it. Success had been attained by both methods.

Mr. G. S. Roberts (Messrs. A. Roberts & Co., Ltd.) said that with the rapid development of internal combustion engines the question of the economical storage of oil became of enormous importance. If concrete tanks could be used to store oil, instead of steel tanks, this would be a distinct step forward in the development of concrete. Before it could be used for this purpose, however, it must be rendered immune from the action of oils. His firm had patented two compositions, namely, "Recelt," for rendering concrete oilproof, and "Kelasto," which rendered it acid-proof. As to the former, owing to the peculiar capillary properties possessed by oils, an ordinary watertight concrete tank was useless for the storage of most oils, and "Recelt" was mainly used for making the tanks suitable. After referring to an underground tank in reinforced concrete, which was being constructed for the Home Office, he said that tests had shown that it was possible to store alcohol, vegetable oils, fatty acids and oleates, even at boiling point, in concrete tanks treated with Recelt. Similarly tests with "Kelasto" had shown that it was possible to store in concrete treated with this composition caustic soda, ammoniacal liquor, creosote, sulphuric acid and solution of soda.

Major W. H. Smith (Triangular Concrete Construction Co.) said the filling of voids in concrete by the use of smaller aggregates was indisputably essential, but there was also a good deal to be said for ensuring that the various particles composing the mass were properly compacted. He said he had designed machinery which applied pressure simultaneously to the two extremities of a concrete block mould, thereby halving the effect of the frictional resistance of the surface of the mould, and consequently halving also the irregular consolidation. Illustrating the quality of the material manufactured by his process by means of lantern slides, Major Smith said that as the concrete blocks were extruded from the mould by the machine the concrete could be made much wetter than in the semi-dry machine, from which it was necessary to pull the sides of the mould away from the block in order to remove them. He maintained that a block made of wetter aggregate was far more impermeable than one made semi-dry since in the latter full advantage was not obtained of the chemical action set up in cement by the application of a sufficient quantity of water. With his machine the material could be made so wet that the cement could be seen to ooze from the sides of the blocks when they were being extruded, and yet the blocks were sufficiently rigid to retain their shape whilst being removed. Again, whilst the blocks were actually being extruded the faces were virtually undergoing a trowelling treatment, which tended to bring the cement to the face, and also to close the pores of the face, and so form the skin which one got with wet concrete.

The President said he had seen blocks made of clinker concrete under pressure of 40 tons. These had been used for the external walls of cottages, and after nine years the inside of the cottages was still perfectly dry, which showed that concrete, although made of porous materials, could, under pressure, be made as impermeable as ordinary brickwork.

Mr. E. Gordon Boyd (Castor Waterproofing Co.) agreed that concrete could be made waterproof, but with ordinary commercial methods the concrete supplied was rarely what had been planned in the office of the engineer or architect. Photographs were shown on the screen of a job in connection with which "Castor" had been applied just before the war, and the work was still in the same condition as when the Castor Company had left it.

Dr. W. R. Ormandy (Torbay & Dart Paint Co.) expressed his disappointment that the author had not dealt with the subject from the point of view of the nature of the constituents employed in making waterproof concrete, because the physical properties of the concrete must bear a very distinct relation to the chemical and physical characters of the materials employed in producing the waterproofing effect. He thought it might be accepted that the comparative strength of cement was rendered less if a material were put into it which had of itself no great strength characteristic, and he did not think it could be claimed that the introduction of a soap material into concrete would add to the compressive strength. The author had referred to the fact that quicklime and clay were claimed by some to produce a strengthening effect, whereas others said that these materials must not be used. If, however, they had a graded lot of materials, the amount of the voids and their size, even if there were perfect contact, must be settled finally by the size of the smallest particles. If one could imagine very fine sand magnified so that the smallest particles appeared the size of your fist, one would see spaces between, and in so far as such spaces could be filled with finer material it was good. Of such materials quicklime was more or less a pseudo-colloid, and clay was a colloid substance. Where it was not present voids occurred, and if these voids were filled with soap, almost certainly the compressive strength of the product would be reduced. In addition to that, knowing what we did about the chemical properties of those bodies, we saw that things which acted on them—as did certain oils, or water containing certain acids—must inevitably in the course of time remove them, and leave the material with more voids than would have been the case if they had never been present. Dealing with the testing of materials, he had been requested to carry out experiments with a material called "Novoid." He had made enquiries as to tests already carried out, with the result that he was encouraged to start experimental work himself. As to such tests, the problem the members of the Institute were up against was that of how to carry out tests in such a manner that the results would be beyond all possible reproach. This should be done by ensuring that the same methods of mixing and the same aggregate were employed, that adequate time was given for the material to get hard, and that it was then subjected, under the observation of some independent person, to all sorts of chemical and pressure tests. He agreed with the author that experiments should not be carried out with water, but with petrol or some neutral material under pressure. It would be advisable to use petrol which had been dyed with an oil-soluble dye, so that one could really see what penetration occurred. There was room for a lot of research that could be done under the aegis of the Concrete Institute or a similar body, and much research could be made at comparatively small expense.

Mr. C. T. Lewis said they were all agreed that concrete made in a laboratory with the addition of the minimum amount of water to the maximum amount of Portland cement was impervious. They also knew that work in the field, dominated by human, fallible hands, indicated the necessity, not so much of a waterproofer, as of a lubricator. Ordinary Portland cement did not flow; consequently, too much water was usually added, producing voids and lowering impermeability. Therefore, a material like "Toxement," or of an oleo-resinate nature, which densified and lubricated at the same time, was of paramount importance. As to the action of sea water on concrete, in 1912 the United States Navy Board had found that in Nos. 1, 2 and 3 dry docks the concrete had disintegrated through the action of salt water. Dry dock No. 4 was then being built of granite backed and waterproofed with Toxement, the bottom not being so waterproofed. After five years the water had attacked the bottom, but the sides remained untouched until this day. The greatest problem of all was the construction of foundations, vats and storage buildings for chemicals, proof against acids and alkalies under normal conditions. Up to within a few years ago no one had thought of building storage warehouses for nitre cake—an acid sulphate of sodium containing as high as 30 per cent. of free sulphuric acid—yet it had been found possible to build successfully such a building, in which nitre cake was housed, and the walls and floors of concrete were not attacked. In such a case as this it was necessary to use two methods. One was integral; the other was the application of an acid-proof surface coating. Fuel oil offered a similar case. Heavy fuel oil could be stored in any concrete tank without injury, but thin oil soon destroyed the crystalline structure of the Portland cement and leaked through. Here also the two methods were necessary, i.e., the integral and the surface coating. Factory floors should stand the maximum amount of wear and tear, be dustless, and be oil and grease-proof. The two methods, integral and surface treatment, should be used according to requirements. External concrete walls should be protected against sulphur fumes, for civilisation was a great destroyer of building materials.

Mr. Harold P. Brown said his method was to mix concrete under pressure with super-heat, thereby mixing the silicates, and to use a jet of superheated steam to project the concrete on to the wall or shutter. Thus he got very great density, and in that way obtained strength and waterproof qualities. The measure of the density could be judged from the fact that, using ordinary sand and ordinary pebbles, which would go through, say, a ¾-in. mesh—with a mixture of one part cement, five of sand and one or two of pebbles—in thin slab work, a material was produced weighing 171 lb. to the cubic ft., whereas the same materials mixed with a machine in the ordinary way produced a slab weighing only from 135 lb. to 140 lb. to the cubic foot. By this method each little grain of sand or pebble was coated with an infinitesimal amount of cement, just enough to make it adhere to its neighbour, and the blow of the striking against the wall or shutter served to tamp it, and that tamping was increased by the pebbles in the compound, which forced the mortar into very intimate association with itself. In that way waterproof results were obtained without grading the sand. During the war he had even had to put concrete on the invert of a stone bridge, with 82 ft. span and 150 ft. width, carrying a canal. Through this bridge water was pouring to such an extent that it was threatening the structure as a whole; but the Government would not shut down the canal, as it was using it for transmitting munitions. He had been asked to go underneath and put on 4 in. of concrete from the bottom and stop that flow of water. He superheated steam to about 300 degrees F., and turned it from below on to the arch, and so heated the stone to about the same temperature. He then jetted concrete on to the lower side, and this had adhered and stood before the stone could cool and allow the water to come through. That gave him the opportunity of putting from 4 to 6 in. of concrete on the lower side of the arch from end to end, stopping the water from coming through anywhere.

A Member said there had been a new product made in Germany before the war. If one could bind particles together with pure silica it would be an ideal substance for waterproofing and stopping chemical action, because silica itself was so resistant. The Germans had succeeded in making a 30 per cent. solution of silica, which was a fluid solution. It could be poured into stone, and in the course of two or three days the silica polymerised into a gel. One or two treatments made an almost pure silicious surface. It was a process used for the preservation of monuments and works of art, where cost was not an important consideration.

THE LECTURER'S REPLY.

Mr. Andrews, replying, hoped the wish that had been expressed by Dr. Ormandy that the Institute should undertake some standardised tests, might bear fruit in the near future. Reference had been made to the danger of damning a commercial enterprise by the publication of a scientific report, but he personally had no hesitation in believing that if it were in the interest of science to bring to public notice what tests had proved to be facts, then the personal convenience of any individual must be left out of account. He thought the American Bureau of Standards—much as he appreciated the work it had done—was less careful than he would be in issuing a damning report on rather slender evidence. If the Institute undertook to make a report in which the names of materials were mentioned it should be exceedingly careful of its ground before issuing an unfavourable report. Continuing, Mr. Andrews said that a recent visit to Italy had shown him that there was a greater appreciation of concrete construction in that country than here. In some respects Italy was a conservative country. They might see a donkey drawing water from a well for a lemon plantation, but within a mile of that could be seen reinforced concrete work going on. In every railway station he had stopped at in Italy there was a concrete water tank. One interesting feature that had struck him was that they got excellent concrete material right along the Mediterranean coast. The mountains were quite near the coast, and streams came down every few miles. At the time he was there these streams were practically dry, and wherever concrete work was going on carts could be seen in the beds of the streams and men shovelling up the stuff into the carts. At the flood period the rivers drove the rock down from the mountains, and in the process of being driven down it became beautifully graded, so that in Italy people started with excellent concrete material right at their door.

The Helical Bar and Engineering Company have removed to more convenient offices at 72, Victoria Street, S.W.1, to which address all communications should henceforth be forwarded. Telephone numbers and telegraphic address remain unaltered.

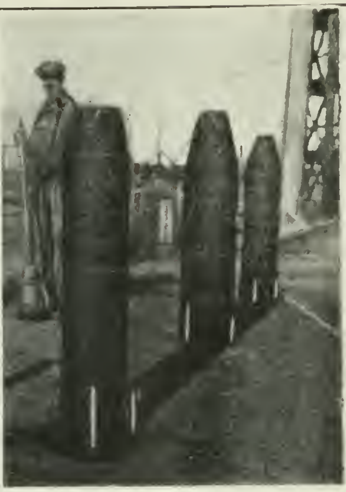


FIG. 1. TAR PAPER CORES FOR THE LOWER SECTION OF THE PILES WITH WIRE MESH ENCLOSED READY FOR THE FIRST APPLICATION OF GUNITE.

SOME NOTES ON PILING.

In a recent issue of "Concrete," U.S.A., some interesting particulars and illustrations appear regarding concrete piles built on paper cores, and the concreting of wooden piles. We are indebted to the above journal for our information and illustrations.—ED.

HOLLOW CONCRETE PILING.

HOLLOW concrete piles built up on paper cores with the use of the cement gun have been used by harbour engineers in constructing foundations for the Vegetable Oil Co.'s plant under construction at Wilmington, Cal. The complete piles are built up over hollow paper cores, constructed in sections and used as a backing in shooting the gunite.

In constructing the piling the foot or base of each pile is built up first and is about four or five feet long. The core for the longer part or body of the pile is constructed in sections each about 10 ft. long.

The hollow cores are made of tarred paper rolled on wooden cylinders and wired. A strip of paper as long as the section is rolled around the cylinder longitudinally and glued along the free edge. This is wired in three places and then covered by a narrow strip of paper wound on diagonally, similar to the bandaging of a broken arm. The cylinder is revolved as the paper is wrapped around it, and hot glue is applied with a brush to each lap of the paper as it folds down on the shell. Wire running off a reel is applied in the same manner as the paper strips, as the cylinder is revolved.

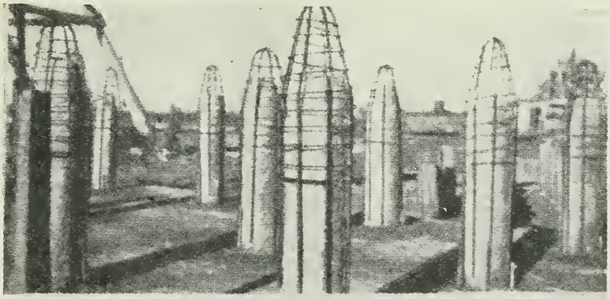
Three thicknesses of paper are put on in this manner and wired and the core is then slipped from the cylinder. It is next encased in wire mesh, which serves as reinforcing for the gunite.

For the foot of the pile the core is built up in the same manner, and a sort of pointed paper cap is formed over one end of the cylinder and covered with the wire mesh, as shown in *Fig.* 1. The sections of cores are next placed on end on a wooden platform, with the pointed end up, and are ready for shooting with gunite. The mixture of cement, sand and water is applied by the aid of the cement gun, using air pressure of 35 lb. per sq. in. The man with the hose walks around the pile section, applying an even coat all around. After the first coat of gunite is applied, the casing of reinforcing rods is slipped over it. More gunite is applied until a bulbous sort of hood is built over the top, which gives this section of the piling the appearance of an overgrown mushroom. This forms the point of the pile.

When the base sections of the pile are completed they are wheeled to the pile moulding rack, a sort of scaffolding high enough to accommodate the 60 ft. piles. The bottom section of the pile is placed in a compartment of the moulding rack, resting upon a reinforced concrete foundation, which prevents the pile from sinking into the soft earth as the weight is increased by the application of the gunite.

The sand used is shovelled directly from the car into the conveyor, which carries it to the bin in the moulding rack. It is then screened and is ready for the hopper of the cement gun, from which, together with the cement, it is forced through the hose by the air pressure.

The longer portion of the core is next added in 10 ft. sections, and the reinforcing rods are wired together. The first section is wired to the reinforcing in the footing, and the shooting of the long section begun. The cement gun remains on the ground and the hose is carried up the various storeys of the moulding rack until each completed pile is built up. An iron head is set in the top of each pile to resist the impact of the pile-driver.



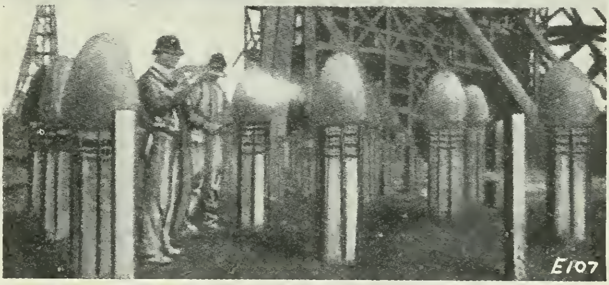


Fig. 2. Piling Encased in Reinforcing Rods ready for further Application of Gunite. Fig. 3. Using the Cement Gun in Building up the Points of the Piles.

When the work of making these piles was first started, the piles were placed far apart in the rack, but after some experience it was discovered that a number of piles—in this case six—set close together, offered a broader surface for the gunite to play against and made less work for the operator. As a result the piles are now set just far enough apart to prevent their touching when completed to their full size.

As soon as the piles are completed they are lifted by an Ohio steel crane, termed "the ant-eater" by the workmen on the job, and transferred from the side of the moulding racks to the pile curing rack some distance away.

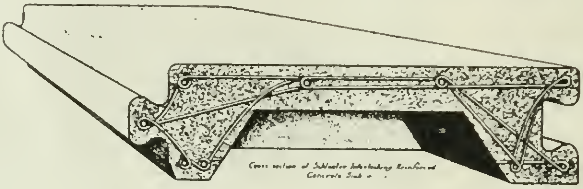
The finished piles are about 60 ft. long, and from 18 in. to 20 in. in diameter, weighing about 6 tons each. Two hundred and sixty-six of these piles are required for the Vegetable Oil Company's new plant.

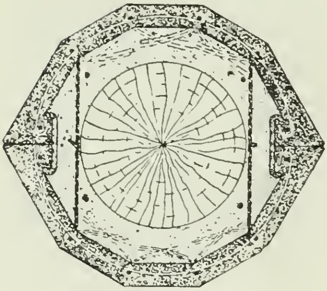
The engineers in charge of the work believe that the piles made with the hollow cores will prove more endurable under the conditions than if made with solid concrete, and state that they are more economical, as less material is required for the hollow piles than for solid piles of the same strength.

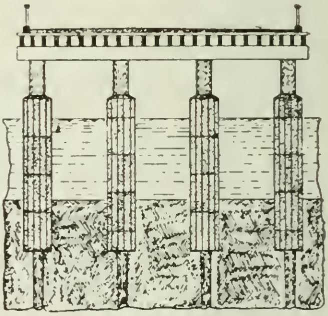
The type of construction was worked out by J. W. Ludlow and the field work is being carried out by V. S. Stirling, F. W. Wadleigh, and Charles Dana.

New Method of Concreting Wooden Piles.

A new method of concreting wooden piles to reinforce and preserve them, has been devised by Mr. Henry W. Schlueter, a Los Angeles engineer, whose system is being used in the construction of the new sea wall at Long Beach. It frequently happens that in wooden piers a few scattered piles are damaged by teredos or weakened by decay of the wood, and it is necessary to replace or strengthen them to save the structure. Replacing piles under such conditions is expensive and often difficult. Mr. Schlueter's method of reinforcing and preserving such piles obviates some of the difficulties of this work and makes it possible to do it at a small cost. He estimates the cost at about $2 to $2.50 per lin. ft. of piling concreted, this figure being subject to slight fluctuations, depending upon the character of the work and availability of materials.




Cross Section of Wooden Pile Concreted by Schlueter System

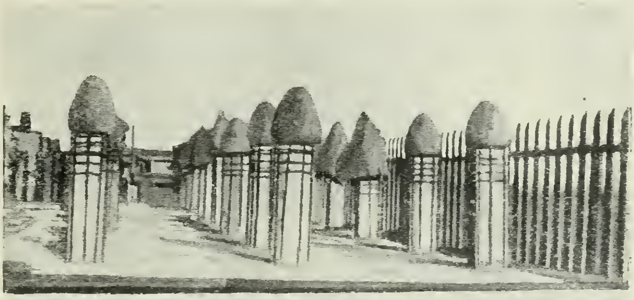

Bent of Wooden Piles Concreted by the Schlueter System.

Details of Protected Wooden Piles.

Mr. Schlueter's first experiments in concreting wooden piles were made with a sheet-iron form as a container for the concrete. This was not found to be satisfactory, because the concrete when so placed could not be reinforced and the sheet-iron form soon rusted away, allowing the concrete to disintegrate. His new method involves the use of a precast reinforced concrete form, or circular shell, cast in two sections and in units of 3 ft. or less. These forms are reinforced with vertical steel bars and horizontal wire wrapping fastened to the bars with wire stirrups, which project on the inside of the form and are embedded in the grout between the form and the pile. Where the sections join there is an interlocking flange on the inside of the form, over which a clamp is fastened, holding the two sections together. There are also stay wires on the inside of the forms, which are joined at the ends and twisted to hold the forms in place when they are first set up. The accompanying illustrations show a cross section of a concrete pile and a bent of concrete piles.

All the concreting work is done from a scaffold swung beneath the pier. The bottom forms are placed first, one being a full length unit and the other a half length unit, so that the entire series of forms are staggered when placed, the horizontal joints on each side being the middle of the forms on the other side. Boards are fastened on the bottom of the first forms, and a canvas flap encircling the wooden pile is attached to the boards at the rim of the form. When the pouring of the concrete grout is started the canvas is forced down and makes a tight bottom, so that the concrete will not seep through.

The concrete grout is poured as each unit of the form is set in place, the grouted form being dropped down as the work proceeds. When the form reaches the sand it is jettied down to a point below the scouring line. The work is performed quickly and the entire form is placed before the concrete grout begins to set, so all voids inside the form are filled and the wooden pile is entirely covered.



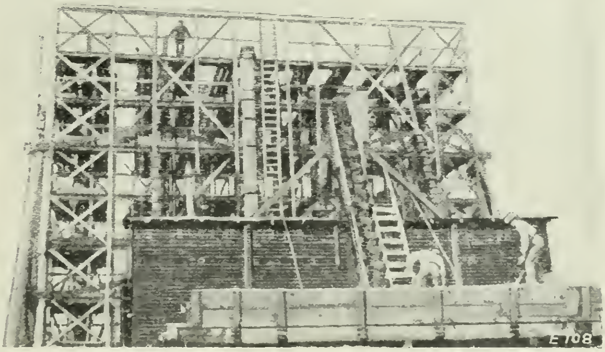


Fig. 4. Completed Pile Points ready for Transportation to the Pile Moulding Rods. Fig. 5. The Pile Moulding Rods.

A rich concrete mixture is used for the forms, making it dense and impermeable, so that the reinforcing steel will be protected from corrosion by the salt water. The grout consists of 40 parts of cement to 60 parts of sand, no coarse aggregate being used, so that it will pack in solidly, leaving no voids. The ends of the form units are smooth, making a tight horizontal point, and strips of felt are placed in the outer edges of the vertical joints to make them tight. The forms are approximately 1¾ in. thick and the grouting space is sufficient to give a minimum of 5 in. of concrete around the entire length of the pile to be protected.

Ordinarily the concreting will not extend above a height to which protection is needed. However, it may be carried higher and a concrete girder may be on top of each bent, making a reinforced concrete structure to support the deck.

RECENT VIEWS ON CONCRETE CONSTRUCTION.

THE SOUTH WALES INSTITUTE OF ENGINEERS.

The following is an abstract from a Paper read before the above Institute. We are indebted to the "Colliery Guardian" for our particulars and illustrations.

THE APPLICATION OF CEMENTATION TO MINING.

By H. STANDISH BALL, O.B.E., M.Sc., Etc.

The benefit of using cement as a means of sealing off water in engineering operations was recognised on the Continent many years ago. But cementation was not recognised as an important asset in mining until the year 1896, when Monsieur François proved that it was possible to bore and inject from the inside of the shaft below the permanent water level.

The François Process.—The process was first introduced in England in 1911, and, curiously enough, the serious setback which it immediately encountered ultimately led to its greatest success. The first sinking essayed was in the new red sandstone district of Yorkshire, the sandstone being of a porous nature readily permeable to water. On endeavouring to treat this ground it was discovered that it was difficult to inject any cement at all, and impossible to introduce sufficient to produce the desired effect. A specimen of the ground was consequently taken and experiments made with various chemicals to discover a compound which would render the ground more tractable to treatment. After much patient investigation success was attained, and by means of the François cementation and silicatisation process the sinking was carried out.

At the present day specially constructed pumps, capable of exerting a pressure up to 4,000 lb. per sq. in., are used, high pressures being necessary to overcome the pressure of the water in the larger fissures, and to ensure that the cement is in direct contact with the ground in even the smaller ones.

The shaft is sunk by ordinary methods until the presence of water is indicated by means of boreholes. A number of holes are then bored in the shaft bottom, pipes being cemented in them, their number, position and inclination being dependent upon the size of the shaft and the character of the strata. Through these pipes boreholes are sunk by means of a diamond drill. On the tapping of a feeder by one of the holes, boring is immediately stopped and the pipe in the hole connected by means of a length of high pressure flexible hose to a column of pipes in the shaft, leading in turn to the cement pump and mixing tank on the surface. Fine cement pulp is injected into the hole, the percentage of cement and pressure necessary increasing as the injection approaches completion.

In addition to sinking, cementation can be applied with success to the solution of a number of underground problems, notably the "drying of shafts," the extinguishing of fires, and the construction of dams.

Drifting in Fissured Ground.—Before a definite programme of injection can be decided on, all possible information must be obtained from geological sections and test holes. In the example chosen for description a 12 ft. by 6 ft. drift was being sunk by a colliery at a dip of 23 degs. for the purpose of working a seam of coal existing at some considerable distance below the bottom of the shaft. Shortly after commencing, water was tapped in large quantities in the Pennant rock, many faults and fissures being proved, rendering drifting difficult and the question of pumping cost one worthy of serious consideration.

From the information obtained it was decided to "drift" in lengths of 25 yds. A "test" hole was first bored for a distance of 80 ft. to 100 ft. to give a rough estimate of the amount of water likely to be met with, each fissure being treated by injection. Eleven holes were next bored in the face to a depth of 5 ft., and 2 in. diameter pipes cemented in, the position and dip of these holes being so chosen as to ensure every fissure in the neighbourhood of the drift being sealed up. For this reason holes 1 to 4 were called the "bottom holes," being bored at a dip of approximately 45 degs., holes 9 and 10 the "middle holes," with a dip the same as the "drift," and holes 5 to 8 the "top holes," with a dip considerably less. Hole No. 11 was known as the "test hole" and was the final hole to be treated, it being actually a hole to prove whether the cementation of the "length" was satisfactory. The flank holes were inclined slightly outwards to ensure that a "plug" of treated ground should exist in the neighbourhood of the "drift."

The dip of the holes was in every case varied slightly, in order that as much information as possible should be obtained about the existing fissures. The bottom holes were first bored and injected, followed by the middle flank holes and finally by the "top holes," the "test" hole being reserved for the last.

The plant used for cementation consisted of a Sullivan diamond drill, a double-acting high pressure ram pump, and two cement mixing tanks, with a plentiful supply of water and compressed air at a pressure of 80 lb. per sq. in. In boring in ground of so hard a character as the Pennant rock, it was found necessary to use diamond drilling extensively, the setting of the crown being one of the most important items in the daily routine.

The injection in many cases lasted for several hours, the final point being decided largely by the reading of the pressure gauge on the pump and general knowledge of the ground, the percentage of cement being gradually increased before the end. Before uncoupling, water was injected to clean out the pumping system, and the cement allowed to set for a few hours, while boring proceeded in another hole. After a period of 8 to 12 hours, the cement was cleaned out by "jumping" with a chisel bit attached to the long boring rods; should the fissure have been satisfactorily sealed off, boring was continued until a further fissure was tapped, when injection would again take place.

Approximately 67 per cent. of the total cement was injected into the "bottom holes," the ground being of a very broken nature; the injection of these holes greatly assisted the treatment of the others, the cement travelling up the fissures and sealing off a large portion of the water. The holes were carried considerably farther than the actual distance of the "length" itself, it being necessary to have a plug of treated ground as a safeguard when the cementation of a further "length" should take place.

On the conclusion of the "drifting" of one "length," less than 2 gals. per minute remained of the 160 gals. per minute met with by the boreholes. This extremely satisfactory result was accomplished by the injection of a total of 19½ tons of cement.

Ordinary mining methods were adopted in "drifting" through the treated ground, the roof being supported by girders resting on brick side walls. "Drifting" by the method described proved to be an unqualified success throughout, the great saving in the cost of pumping being self-apparent.

Sinking in Fissured Ground.—A very large amount of the work accomplished by cementation, particularly on the Continent, and in South Africa, comes under this heading. The principle of working is the same as in the case just described, and consists in sealing off the fissures in the ground by injection before sinking.

In an example chosen for description a 12 ft. diameter shaft had been sunk for a distance of 63 yds. without any accurate knowledge of the ground having been previously obtained. Soon after sinking was commenced, water was met with in the shales, the quantity rapidly increasing as the sinking proceeded.

As it was estimated that the majority of the water was being made through a large fissure in the shaft bottom, it was decided to seal this off by means of a concrete plug before the shaft walls were treated. Without dewatering the shaft, the shaft bottom was cleaned as well as possible, six 1½ in. diameter iron pipes being then suspended inside the shaft, three of them being some 6 in. from the bottom and three about 2 ft. The last 20 ft. of each length of piping consisted of 3 in. diameter pipes, so as to allow of diamond drilling through them during the treatment of the ground underlying the plug. About 100 tons of rock were thrown in, care being taken to distribute it evenly, the amount previously having been calculated to form a plug of about 15 ft. in thickness, sufficient to seal off the fissured portion and stand the static pressure. Cement was injected through the six pipes into the mass of rock, this being continued until signs of cement on top of the plug became evident; 42 tons of cement were injected in this manner, the first two holes receiving the greatest amount, the whole injection only taking 14 hours. At the conclusion the shaft was allowed to stand for a month to permit the concrete plug to set. On the dewatering of the shaft it was found that a number of comparatively large feeders existed in the sides above the top of the plug, several of them averaging 50 gals. per minute. Six weeks were spent in treating these by means of 20 boreholes drilled in the shaft sides to various depths, sawdust and thick cement being used in many cases to form a foundation for blocking up the feeders.

Before the plug was removed it was found necessary to bore and inject a further 10 holes through the sides of the plug, several small fissures being proved to be in existence. The pipes through the plug were discovered to be in good order, and there was no difficulty in boring through them and treating some 40 yds. of the underlying strata, 142 tons of cement being used during the various injections. The length of the borehole was 41 yds.; water sealed off 70 gals. per minute; cement used 56½ tons; and the time taken for the treatment six weeks.

On the plug being removed the shaft was found to be practically dry, allowing sinking and walling to proceed in the usual manner without pumps, a 9 in. brick lining being put in.

Though the watery measures were considered to have been successfully treated and sunk through, it was nevertheless considered expedient to have pilot holes ahead of the sinking to give warning of further fissures. These were bored accordingly, with satisfactory results, and the coal measures were successfully reached approximately a year after the commencement of the treatment of the ground by cementation, the total water in the shaft being less than 2 gals. per minute.

Sinking in Porous Ground.—In the many types of ground in which cementation has been used, more difficulties have been met with in the treatment of porous ground than in any other. As has been previously mentioned, when sinking by cementation was first essayed in the new red sandstone of Yorkshire it was only possible to shut off 50 per cent. of the total water by cement injections. After a certain amount of experimental work had been successfully carried out it was discovered that by injecting solutions of silicate of soda and sulphate of alumina, followed by cement, it was possible to stop 95 per cent. of the total water.

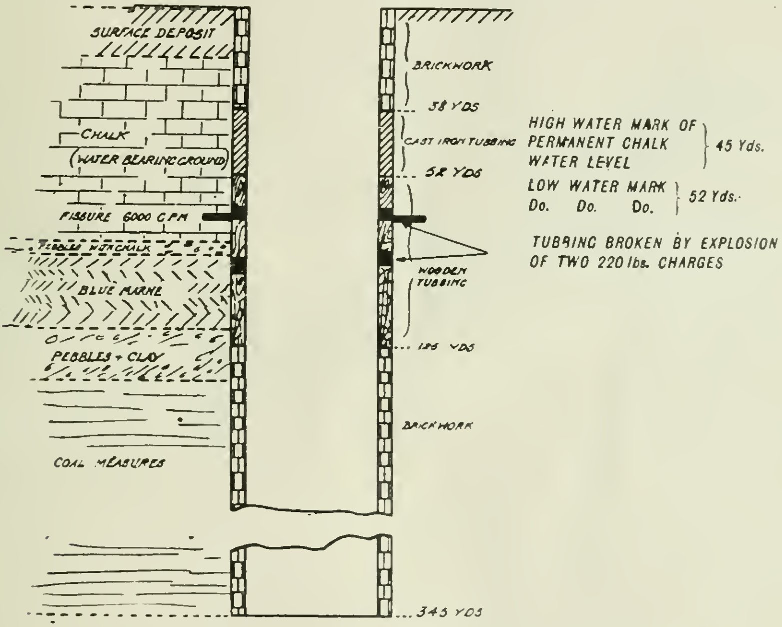
It was found that many of the fissures encountered contained a quantity of loose sand in them, and consequently when cement was injected the sand was forced into the formation of a species of dam, beyond which the cement could not penetrate. The action of the solutions was of a chemical nature, the aluminium silicate formed on their coming in contact with one another performing the duty of a lubricant to the fissure, percolating through the sand and stiffening it to such an extent that cement could be easily injected at less than one-sixth of the pressure previously necessary, the chemical precipitate formed being of a gelatinous nature.

The usual method of "walling" in connection with this treatment is by means of reinforced concrete. It is extremely difficult to lay down any definite programme for treatment by silicatisation, every case having to be treated individually. Naturally the strength of the chemical solutions and the rate at which they are pumped into the ground are important factors.

The case chosen for description is an example of a shaft 22 ft. in diameter that had experienced many vicissitudes of fortune before cementation was adopted. Commenced eleven years ago, it was sunk to a depth of 158 yds., some two years being taken during the sinking, a very great amount of water having been met with in the red sandstone. Cementation was tried at one period, but owing to silicatisation at that time not being in existence, did not prove a success, being due to the nature of the ground. Ultimately it was decided to adopt the "freezing process," the freezing pipes being sunk to the coal measures by a German firm just before the outbreak of hostilities. On account of the war, work was once more held up, and was only recommenced last year, it being finally resolved to carry out the sinking by cementation, a shaft in the neighbourhood having been successfully sunk by this method in ground of a similar nature.

Owing to the extremely fissured and broken nature of the ground in the bottom part of the shaft, a concrete plug had to be placed in position before any cementation could take place. This was inserted in the manner previously described, the plug in this case being very much larger, being fully 55 ft. in length. Several hundred tons of rock were thrown into the shaft, and a large quantity of cement injected through the pipes previously placed in position, the total injection taking 56 hours.

Provided that the ground has been previously treated by cementation, walling with reinforced concrete is rapidly taking the place of cast-iron tubbing. It can be made practically watertight and can stand any static pressure met with in practice with a good safety margin. Several shafts in this country have been lined with reinforced concrete, this type of lining following on naturally after cementation. Several of the pits in the French coal fields destroyed by the Germans are to be relined with reinforced concrete in place of the existing wooden tubbing.



By courtesy of "The Colliery Guardian."]

FIG. 1. SECTION OF A SHAFT, SHOWING TUBBING DESTROYED BY EXPLOSION.

Where water has not been entirely excluded by cementation of the measures, it is subsequently shut off by injections between the completed lining and the ground.

With the exception of earth movement, no pressure can be established on the walling by the water, other than the purely local heads in the fissures themselves. In the case of a shaft lined with cast-iron tubbing, not only is the full static loading maintained during its whole life, but the lining naturally deteriorates with age and change of temperature.

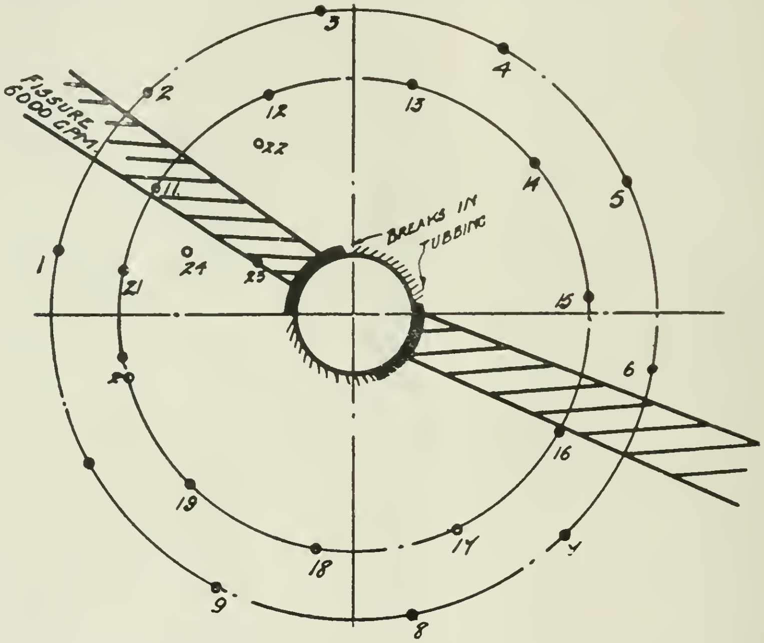
In certain permeable measures, *e.g.*, new red sandstone, cementation is not carried out to the entire exclusion of water for economic reasons; complete security is, however, assured by designing the walling to meet the increased pressure expected.

Of the two types of lining, concrete is decidedly cheaper and far easier to place in position.

Though the design of the reinforced concrete walling is constantly changing in many small details, the main points and principles of inserting it remain the same.

Repairing Pits in the Lens Coal Fields.—Soon after the conclusion of hostilities, Monsieur François was entrusted with the work of repairing several of the shafts in the Lens coal field. By means of suitably placed boreholes and injections of cement under high pressure the water flowing into these shafts was sealed off in a comparatively short time, and the ultimate recovery of the coal greatly expedited.

The procedure adopted in the cementation of each pit differs little in detail; it is therefore only proposed to deal with pit No. 11. When the pit was originally sunk, a very large horizontal fissure was encountered at a depth of 63 yds., a certain amount of difficulty being experienced in dealing with the great amount of water.



By courtesy of "The Colliery Guardian."]

FIG. 2. PLAN OF CEMENTATION HOLES FOR THE REPAIRING OF TUBBING DESTROYED BY EXPLOSION.

This fact was taken advantage of by the Germans, for a charge was exploded in the shaft at the exact depth of the fissure, causing holes 16 ft. by 22 ft. and 19 ft. by 13 ft. to be blown in the sides. It was this break in the tubbing and consequent flooding of the mine that had to be dealt with by cementation.

The accompanying illustration *Fig.* 1 shows a section of the shaft, giving particulars of the shaft lining, ground, and position where the tubbing was blown out by explosion, the lower charge having exploded previously without any very serious result.

Fig. 2 is a plan of the cementation holes, each hole having been bored vertically downwards to a depth of 125 yds., to ensure its reaching below the bottom of the water-bearing measures.

The diameter of the shaft was 16 ft., that of the outside circle of holes 84 ft., and the inside circle 67 ft. The outside circle was injected and finished before the inside one was commenced. The holes were treated in pairs, being situated on opposite sides of the shaft, the one being bored while the other was being injected. An average of 14 injections was found necessary in each hole, the injection commencing at a depth of 39 yds., and being repeated about every 5 yds. down, whenever water was being made in the hole. A total of 340 tons of cement was used for the outer holes and 101 tons for the inner ones. When injecting, the pressure was not allowed to rise above 200 lb. per sq. in., this being found ample for the type of ground under treatment.

One foreman and 11 men were employed on each shift, the total time taken for the completion of the work being just under three months. The following particulars of cement injected are interesting, as on referring to *Fig.* 2 they show clearly the amount of cement taken up by the fissure :—

Hole.	Cement injected. Tons.	Hole.	Cement injected. Tons.	Hole.	Cement injected. Tons.
1	56	9	30	17	14½
2	51	10	34	18	8
3	19	11	8	19	5
4	19½	12	17½	20	10
5	18	13	6½	21	8
6	41	14	4	22	2½
7	40	15	8	23	¼
8	33	16	20	24	1½

On the water level in the pit falling sufficiently to allow of the tubbing break being examined it was found that the flow of water had been completely sealed off, and in the place of the 6,000 gals. per minute feeder which was visible in the shaft on its previous examination three and a half years before, there was now only a small feeder of 25 gals. per minute, this latter being entirely sealed off after a few hours' further injection.

The majority of the pits were damaged by the Germans towards the end of 1915, and in consequence it had been found that at times the wooden tubbing had suffered considerably. In such cases the affected parts were treated by injection from the inside of the shaft.

General Mining Work.—*Drying of Shafts.*—Though drying of shafts may be termed a side line of cementation, yet there is no doubt that many shafts in this country have been greatly improved by the application of the process.

Owing to the contraction and expansion caused in the lining by changes of temperature, leakages often occur which cannot be treated satisfactorily by wedging. By the boring of holes in suitable positions and injection of cement such shafts can be rendered perfectly dry.

Cementation can be further applied successfully in cases where tubbing plates have been broken, the removal of the defective plates thus being rendered unnecessary. It is difficult to give any costs for drying of shafts, but the following example is fairly typical.

One hundred and fifty yards of lining in each of two shafts was in poor condition, a quantity of water approximating to 2,500 gals. per hour being made in each shaft. In two and a half months 97 per cent. of the water was shut off, the work being done at nights and during week-ends. The total cost amounted to £3,600, or £12 per yard, being made up as follows: Labour and supervision, £2,050; cement, £1,150; materials, £400; total, £3,600. It is worthy of record that some 40 shafts in England have been dried by cementation during the last few years.

Underground Dams.—Dams have lately been constructed in which cementation plays the chief part, the space between the face of the working and a strongly constructed brick wall being filled with rubble, pipes having been previously placed in position for the purposes of injection. On cement being injected a solid mass of concrete is formed, impervious to water.

Underground Fires.—By means of cement injections dams can be rendered absolutely airtight. On one occasion a fire had been burning in a main cross drift for a number of years, the arching having to be constantly renewed in consequence. Ordinary 2 in. diameter pipes were finally put into the roof between the steel girders, some of them penetrating through the timber for a distance of 10 ft. to 12 ft. above the steel bars supporting the roof. On the injection of cement the many small fissures which showed up became blocked, and after a week's treatment the fire was extinguished.

Miscellaneous.—Cementation has been used in a variety of engineering problems besides those that come under the heading of mining.

Work of a somewhat unusual character has lately been carried out in France, it being found possible to inject gravel with cement under pressure from the surface, thus changing it into a species of concrete, suitable for heavy foundations.

The consolidation of the foundations of a surface dam by means of the injection of a number of short boreholes was recently carried out in Africa.

A case of the prevention of " creep " and " thrust " at a shaft bottom occurred a short while ago in a colliery where, owing to the presence of water at the shaft bottom, the surrounding shale had been caused to swell, affecting in turn the roof of the arched shaft siding, which showed signs of serious collapse for a considerable distance. In spite of the concrete lining being 1 yd. thick and supported by girders, the strain was so great that a shield of wooden lagging had had to be constructed as a safeguard against the pieces of concrete which were continually flying off. As it was difficult to tell at the commencement of the work where the water actually was, three holes were bored vertically upwards for 120 ft. at a distance of 20 yds. from one another without, however, tapping any water. Holes were next bored vertically down, water being met with at a distance of 12 ft. Three series of holes were then bored : Series 1 straight down, series 2 at a dip of 45 degs., and series 3 horizontally, each hole being approximately 3 ft. from its neighbour. The holes of series 1 were treated first, followed by series 2, and finally by series 3. The whole affected area was treated in this manner, some 600 tons of cement being injected at a maximum pressure of 300 lb. per sq. in. At the conclusion of the injection the key of the arch was replaced by a fresh one, further cement being injected through holes in the roof to render it as tight as possible. Although only two months were taken over the work, the whole siding was consolidated, and no further treatment or repair work has been necessary.

Though the improved process is still more or less in its infancy, sufficient confidence has been placed in it to warrant the formation of a powerful London company under the name of the François Cementation Co., Ltd. Perhaps it is not an impossible flight of fancy to imagine at some future date the much talked of Channel Tunnel being constructed with the aid of the cementation process.

DISCUSSION.

Mr. E. L. Hann (Powell Duffryn, Ltd.), in a written contribution, said the very large quantities of water now being pumped both in the Pennant rock and in the shales, could, in all probability, have been sealed off by means of the application of cement, and thus have saved large additional capital expenditure required, in addition to the delay in sinking, as well as the heavy cost of continual pumping. One of the objections raised against cementation during sinking was the delay, and consequently very heavy extra cost, due to stopping the actual sinking work during boring and cementation. Consequently it was advisable that the boring and cementation should be done in as long lengths as possible, and in most cases it would be found that rather than interrupt the sinking and consequently have to employ the sinkers on day work on the surface, it was better to put up with the increased cost of boring to a comparatively great depth. It would be of interest if the author would state whether a fast, medium, or slow setting cement was preferable. The account of the sinking in porous ground by means of silicate of soda and silicate of alumina, was extremely interesting, though the theory that the gelatinous nature of the sulphate of alumina caused lubrication and enabled cement to be forced where it otherwise would not be possible, was somewhat difficult to follow. One could hardly understand how a particle of cement, which could not be forced into an opening under 2,000 lb. pressure, could be helped by the lubricating quality of any material. It appeared probable that whilst the finest particles of cement could not enter the pores of the ground, it was quite possible to inject two liquids which, on meeting in the pores of the ground, formed a precipitate, and consequently blocked the passage of water. The system of lining a shaft with reinforced concrete was one which was likely to be almost universally adopted, especially where watertight brickwork and cast-iron tubbing had been previously used and when it was considered that the reinforcement and back plates acted as a very satisfactory form of timbering. Again in a great many of the deeper shafts in South Wales great trouble was experienced where the shaft passed through coal seams having soft fireclay floors. Under such circumstances there was no doubt that reinforced lining would completely avoid any trouble from "squeeze." However, in the ordinary Pennant and harder zones of the coal measures, it would probably be found that reinforcement was not necessary, and that the shaft could be lined with plain concrete at a somewhat cheaper price and certainly more rapidly than with brickwork.

Mr. W. Forster Brown (President-elect) said he had some experience of the cementation in a case where the pumping method was abandoned after all the pumps were ready, and he must say, the abandonment in favour of cementation was never regretted. The cementation process, however, took a long time to accomplish its work. He asked Major Ball which system of long or short lengths he would recommend to make the best progress where two shafts were being sunk and the ground was favourable. In the case which he had mentioned, the holes were very long, and the point occurred to him whether better progress would have been made with shorter lengths, assuming they got over the difficulty with the sinkers in moving them from one shaft to another. With regard to drifts, the author said the bottom holes were first cemented, and that this helped in dealing with the other boreholes. He presumed that here the water was below the drift and not above it. Presumably Major Ball did not mean they should always cement the bottom holes first in a drift. Another point upon which he would like the author's opinion was whether the cementation of underground gobs was a practical proposition. As was well known, they had great difficulty in maintaining their roads at a reasonable cost, and it had often occurred to him that this could be materially lessened if they cemented the gob at certain distances on each side of the main road. Of course, this would not be a case of providing against water from fissures, but of putting water into ground that perhaps had no water in it before, and the effect upon the road might be unfavourable, because they knew that if they had a coal pillar on each side of a main road on a longwall face, the chances were the road would gutter up in the roof and they had trouble.

Mr. W. O'Connor asked why it was that the injection of cement under high pressure caused the cement to set more rapidly. Did high pressure contribute to a speedier crystallisation of the silicate of soda and sulphate of alumina? He doubted whether in the Pennant strata the process in South Wales was going to benefit collieries as a whole, because their experience showed them they would bring down water in any case, and it became a question whether the saving in pumping and avoiding delays in sinking would counterbalance the cost of cementation during sinking. Major Ball had shown them how the cementation process had been used for consolidating alluvial ground. Would the process be similarly successful in consolidating alluvial ground in the Pennant rock, and how many boreholes would be required in the river bed in order to ensure watertight strata beneath the level?

Mr. W. Cleaver said he did not quite see the necessity of the steel linings for shafts described by the author, seeing that the consolidating effect of cementation was fully established. It appeared to him that the setting of the concrete would be much more effective if the inner steel linings were omitted. As to cementation in gravel, he would like to know if the gravel, after cementation, had proved sufficiently solid to avoid pressure without excavating at all?

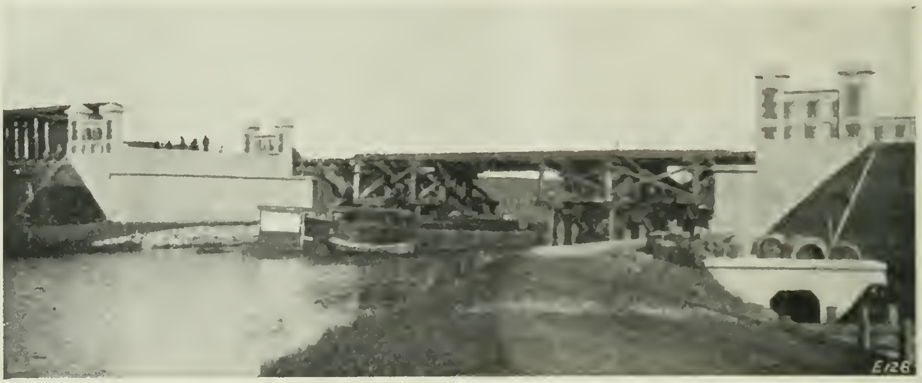
Mr. James Elce stated that in some seams of coal, there was an intervening " bind " or clift, measuring anything from 7 ft. to 13 ft. of very hard rock, and frequently when the intervening stretch between the coal and rock came away there were inrushes of water from the overlying rock. He would like to know if cementation had been tried to consolidate this clift.

The President said he did not know whether it was possible to cut off by cementation the very heavy streams of water in working in the Pennant. He knew of a seam in the Swansea district where the whole of the strata above it to the surface was Pennant rock, and a considerable quantity of water found its way from the surface into the workings, and where a fault was met with it was a very costly matter indeed. With regard to the steam coal measures, he was not aware of any case in which Pennant water had passed through the shales into those measures.

Mr. W. O'Connor said he thought there were such cases.

Mr. F. E. Jacob presumed that the cementation process could be successfully applied to cases in which shafts were being sunk to the steam coal measures from seams already being worked instead of having to pump continuously.

Replying on the discussion, **Major Ball** said as to the use of high pressures in the application of cementation, these were necessary, firstly, to oppose the pressure of water in the rock fissures; secondly, to ensure the cement penetrating into the cracks, and thirdly, to expel the water out of the fissures and so obtain direct contact between the ground and the cementation. Furthermore, under pressure, the consolidation was accelerated. When cement emulsion was allowed to set ordinarily under water it did so very slowly, but when the same emulsion was subjected to pressure, such as that produced by the specially constructed cementation pump, it set hard within the comparatively short time of twenty-four hours. Quick-setting cement was required, especially in fine ground. As to the question of " product," the action was two-fold. In the first place the compound formed into a gelatinous precipitate. In the fine fissures of this red sandstone a lot of particles existed. If cement was injected without this preparation the sand particles banked up and the cement could not penetrate. The first action of the compound was to prevent banking up. The particular strength of the compound formed a hard mass which sealed off the very fine fissures into which it would be impossible otherwise to get the cement. In the first place it was used to clean out these fine fissures, and secondly, to fill them up. Other " products " would, perhaps, do equally well, but they would probably be more expensive. As to the question put by Mr. Elce, the process of cementation had not been tried in such a case as that cited, so that it was difficult to make a pronouncement on the point until the conditions were exactly known. Replying to Mr. Cleaver, it had been found to be uneconomical completely to shut off the water during the sinking. The water was reduced to about 200 gals. until they got down to the required length when the concrete wall was built up. The reason for the back sheet was that the water should not mix up the concrete and wash everything out; it prevented the concrete lining being interfered with by the surplus water. Fine concrete was put behind the back sheets, and injecting through the pipes fill up the space behind the sheets and the side of the shaft until intimate contact was obtained with the ground and the linings. As to cementation in river gravel beds, no complete tests have yet been made, but the experiment had been tried in France. It had not been tried in this country, but work of this nature was contemplated. As yet their only experience of the consolidation of river deposits and gravel beds was the example in France described in the paper. As to the treatment of gobs by cementation, this was a new problem. They had treated water from old workings in sinking by means of rotary pumps and injecting quantities of ashes, shingle and cement to fill up spaces, and afterwards injecting with high pressure cementation pumps. The process was difficult of application to running sand. They were faced with a problem in Kent, where there was about 30 ft. of sand just above the coal measures. They had been working at this for some months, and thought they had at last achieved success. Answering Mr. Jacob, he said he had every confidence that the cementation process could be applied with success after the source of the water was traced. In many instances large quantities of water were met with in shafts, necessitating very costly pumping. In such cases it was an easy job to seal off the water by means of holes bored in the side or vertically from the workings. It depended upon local conditions.

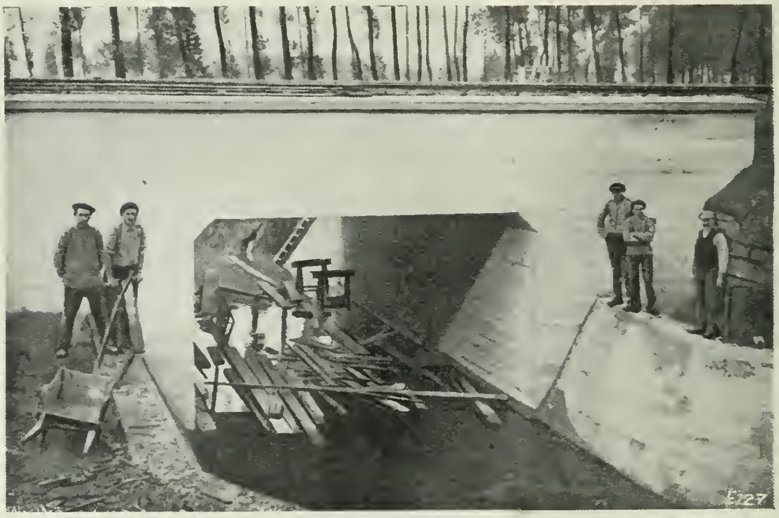


Ends of Flobecq Bridge at Lessines.

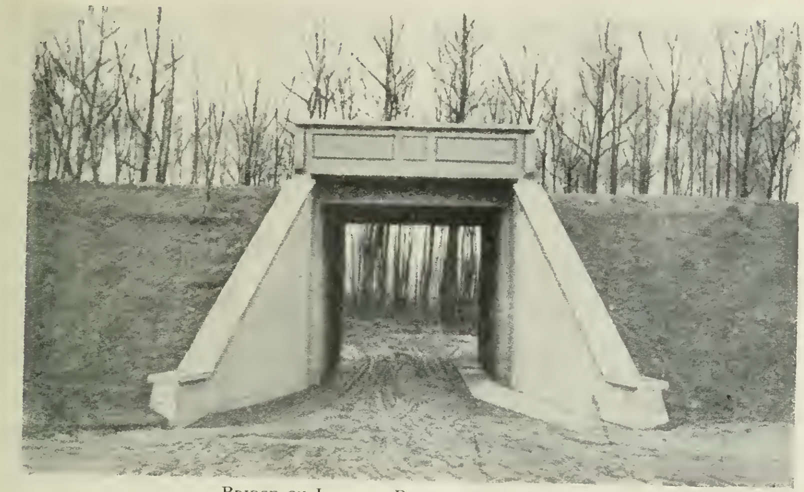
RAILWAY RECONSTRUCTION WORK IN BELGIUM.

So systematically was the German plan of destruction of the Belgian railways carried out, that over a large area not a single rail-joint was intact, not a single bridge safe for transport and few of the roads were passable for ordinary traffic. It was, therefore, necessary to commence the reconstruction work with a minimum of delay and the affected country was divided into various areas, each of these being assigned to a definite firm of contractors.

The quadrilateral area extending from Ath to Leuze, Lessines and Renaix was assigned to the Société Belge des Bétons of Brussels with instructions to erect provisional bridges at once and permanent structures later, so as to ensure the rapid reconnection of the places named, as they were at that time completely isolated. At the same time rivers, roads and railways had to be cleared of débris.



One of the Twelve Bridges between Ath and Leuze.



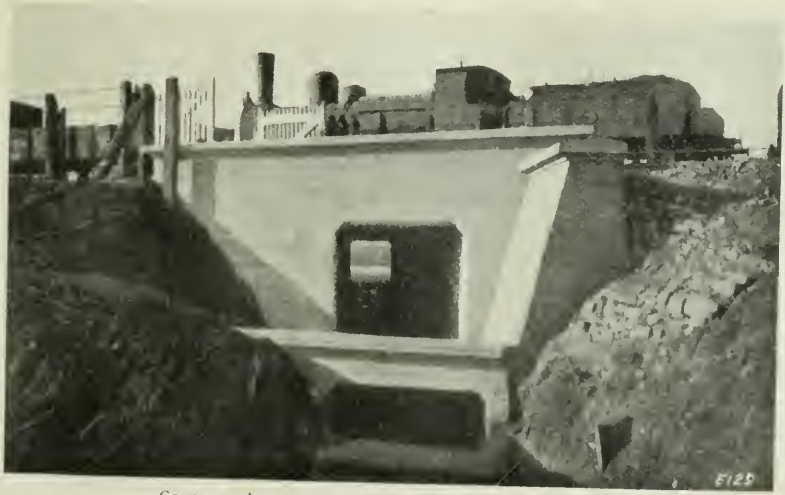
Bridge on Lessines Railway near Flobecq.

In view of the urgency of the matter wooden bridges were first constructed, and so rapidly was this part of the work accomplished that the first large wooden bridge was completed thirty-four days after the receipt of instructions and the three other large bridges were completed a week later, and within two months of the order being given complete communication was restored between Lessines and the other three towns.

For the permanent work concrete was used wherever possible on account of its obvious advantages, and the organisation of the firm was so good that an average of 200 cubic yards of concrete were placed each day.

The work was completed punctually to the date promised notwithstanding many difficulties due to the unusual nature of the work.

The accompanying illustrations show typical portions of the work.



Concrete Aqueduct and Railway Bridge at Lessines.

REINFORCING STEEL CUTTING AND BENDING LISTS.

By H. P. ATKINSON, B.Sc.

In practice the engineer's general plans show clearly the size, dimensions and locations of bends of all reinforcing steel. However, the most efficient results cannot be obtained by allowing the workmen to cut and bend the steel from the engineer's general plans. For one thing, most workmen are—with the exception of very competent foremen of much experience—incapable of interpreting the engineering plans as readily as a trained draftsman, and even were this not the case a complete list showing the details of each bar will result in time economy in preparing the steel. For this reason contractors and builders doing reinforced concrete work can well afford to employ a force of draftsmen, or retain some engineer and his staff, to make up lists showing details of reinforcing steel. Shop details are as necessary for reinforcing steel as are the detailed drawings prepared for the use of a structural steel shop previous to the work of punching and cutting the steel for a bridge, building, or any other structure.

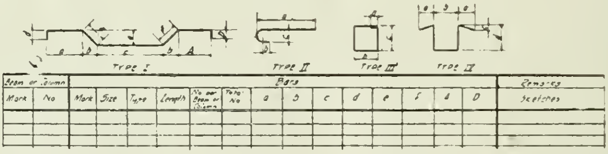


Fig. 1.

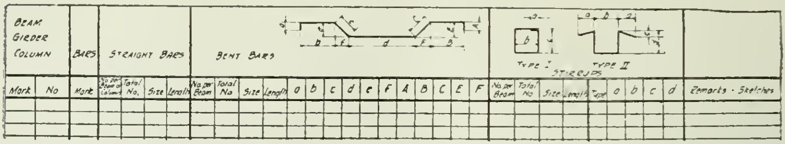


Fig. 2.

The writer has found two forms for these steel lists very popular in the United States, one or the other being used by construction companies handling a large amount of reinforced concrete construction.

In *Fig.* 1, the more common bends are detailed at the top of the list giving each different bend a "Type" number. The essential dimensions are designated by letters—the same letter being repeated in more than one type. Type I is the most commonly used bend as it is repeated many times in beams and slabs; Type II is frequently used for continuity bars in the end spans of continuous beams, and Types III and IV are readily recognised as the two most frequently used form of stirrups. Bends varying slightly from those two may be designated by referring to one of the four "Types," leaving blank any of the dimensions that are omitted from the bends. Take as an example a bend of Type I in which the end hooks are omitted. This can be clearly shown in the bending list by referring to " I " under the column headed " Type " and leaving the dimension columns " d " and " D " blank (or put zero in these columns). Straight bars are so designated by writing the word " straight " in the " Type " column, and special bends not coming under any of the four " Types " can be illustrated by means of a sketch under " Remarks—Sketches," with the dimensions in feet and inches directly on the sketches. If a special kind of bend should occur often on some particular piece of work, it is a good plan to sketch it at the top of the sheet and give it a " Type " number.

This list (*Fig.* 1) is more concise than the list shown in *Fig.* 2, but is not quite as readily understood at first glance. Workmen usually require some practice to become familiar with the former list, although after a little practice both lists are equally simple. In *Fig.* 2 each bend is dimensioned with letters in the illustrations and columns provided to refer to these dimensions as in *Fig.* 1, but each type of bend is given a set of columns to itself and columns are also provided for straight bars.

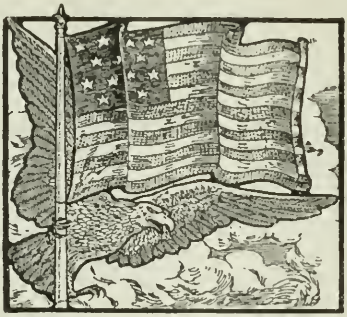
It is customary to print the forms for these lists on thin white paper such that when a soft pencil is used a legible blue print will result. The name of the construction company, initials of the person who makes the list, those of the checker, the date, the file number, the name of the job, and the general plan number from which the list was made usually appear at the top of the sheet.

MEMORANDA.

Reinforced Concrete Wheelways.—In the annual report of the Roads Committee, Upper District of Renfrewshire, the Surveyor, Mr. R. Drummond, states : " It is a difficult problem to provide a surface suitable for both horse and motor lorry traffic ; the action of the horse's shoe tends to cut the sealing coat, and whenever the surface is broken the rubber-shod wheel rapidly causes disintegration, and corrugations are set up, but the problem may be solved by the introduction of ' wheelways.' Experimental lengths of reinforced concrete tracks or wheelways are proposed to be laid on the Paisley and Cowglen roads, and if the scheme proves successful it may meet the difficulty of carrying mixed traffic, and at the same time provide a suitable foothold for the horses. There is a further difficulty in properly maintaining bituminous-bound road surfaces where the roads lie damp or are shaded with trees, and there are several stretches of this nature on main roads in the district, and wheelways may overcome the difficulty there also."

Road Making.—Dealing with this subject in the *North-Western Daily Mail*, a writer refers to the extensive use of concrete for roads in the United States, and points out that although such roads have been laid in a number of places in this country they are, generally speaking, not very much favoured by our engineers and local authorities. In the writer's view this question of road construction should be dealt with either by the Local Government Board or the Roads Board with a view to ascertaining what is the best possible standard of highway.

Concrete Roads in Canada.—The extent to which concrete roads are being laid in Canada was demonstrated at the last convention of the Ontario Good Roads Association by Mr. S. A. Cummiford, Chief Engineer to the Toronto and Hamilton Highway Commission, who stated that in Ontario and Quebec alone there are now 3,000,000 square yards of concrete roads, and that further sections are still being laid. As showing the economy in maintenance costs of concrete roads as compared with macadam roads, he quoted the following figures of the actual upkeep costs of the two types of roads in his own area during the past few years (the figures are per mile) : 1916 : Concrete, 40·14 dollars ; macadam, 1116·17 dollars ; 1917 : concrete, 59·13 dollars ; macadam, 1867·23 dollars ; 1918 : concrete, 60·99 dollars ; macadam, 5721·75 dollars ; 1919 : concrete, 47·96 dollars ; macadam, 6243·25 dollars ; 1920 : concrete, 70·30 dollars ; macadam, 3398·01 dollars.



THE AMERICAN CONCRETE INSTITUTE ANNUAL CONVENTION.

The Annual Convention of the American Concrete Institute took place in February, and we have now received copies of many of the Papers read at this gathering. The subjects dealt with covered a wide field, and it is not possible to reproduce all the papers in these pages.

The following notes and abstracts taken from some of the reports may, however, be of interest.

Contractor's Plant in Reinforced Concrete Construction.

This is a subject to which a great deal of attention is paid in the United States, and the following short abstract and diagrams are taken from the Report of the Committee appointed to investigate this question.

The plant used for handling concrete on building construction is in general basic for all concrete construction, subject to possible variation in the relation of the different units to each other by reason of special conditions existing in different fields of construction.

The operations of unloading, transporting and receiving, as well as the combination function of mixing, hoisting and placing are in themselves subject to a very large number of possible combinations of methods and are frequently delegates to another party, the material dealer, whose price for material delivered may include these two items. A survey of the individual operations showed the advisability of separating in this analysis the unloading and transporting operations from the others. These two operations have accordingly been omitted entirely.

Owing to local conditions or peculiar requirements as to speed, labour saving, or winter weather the various plants in successful operation which were visited and studied during the year, presented such a variety of layouts that it was realised anything approaching a standard arrangement of plant was out of the question. Most of the plant layouts, however, could be grouped into seven fundamental arrangements, and these seven plants as numbered develop from a very elementary form by the addition of equipment intended to conserve labour, thus making possible a comparison between the additional money expended for plant and the saving in labour costs as a result of its use.

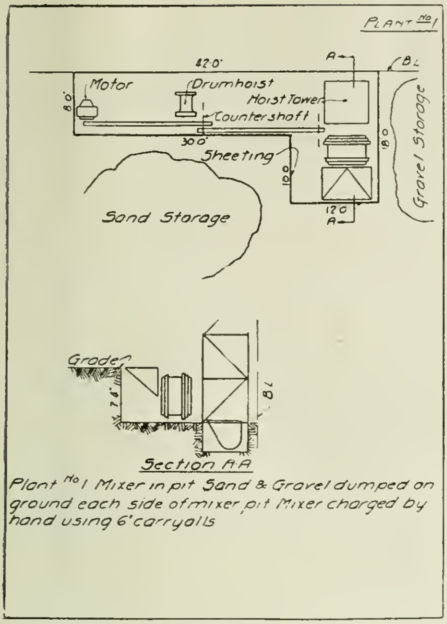
The problem arises as to how much to expend on plant with its installation and operation, so that the cost of the plant installed will not absorb or possibly overshadow all of the savings which its use might be expected to make in labour cost during the course of the job.

Analysis of Jobs by Charts.

In deciding between alternate arrangements of plant for a proposed job it thus becomes necessary to find the cost, per cubic yard of concrete, of the plant installed, as well as the operating cost. To reduce the labour attendant upon making analyses of possible layouts for different jobs as they arise, a graphical presentation in chart form of the required information is suggested, based upon a few general assumptions which make it possible to estimate the average cost of each of these types. The cost, which may be on either a plant rental or depreciation basis, is arrived at and the result plotted on ordinary cross section paper. The use of logarithmic cross section paper reduces these curves to straight lines and facilitates both figuring and plotting, as it is then necessary only to find the cost for the limiting yardages, which in the cases presented are 1,000 and 3,000 and 3,000 and 15,000, a change in the size of the mixing plant being assumed at the 3,000-yd. limit.

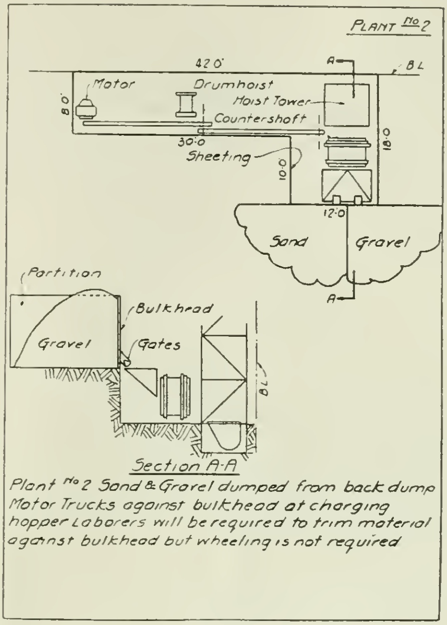
For the purpose of illustration the seven typical arrangements of plant have been analysed. It has been taken for granted that on jobs of less than 3,000 yds. a ¾ yd. plant would be used, with 50 ft. wood tower, 8 carryalls for placing and 300 ft. of run panels assumed as the average equipment. Jobs over 3,000 yds. would have a 1 yd. plant, wood tower averaging 125 ft., 12 carryalls for placing and 400 ft. of run panels. As many contractors standardise on 1 yd. chuting equipment, this has been used for both ¾ yd. and 1 yd. plants, but with a 100 ft. steel tower for the ¾ yd. and a 180 ft. steel tower for the 1 yd. plants.

These assumptions are for an average of several conditions. A building of any yardage may be of large area and limited height, or of many storeys on a restricted plot. Variations from the average in the case of any job of medium size involve a difference in cost per yd. which is usually very slight when pro-rated over the entire yardage. On extensive operations a slight difference in cost per yard between several possible plants would naturally warrant a careful individual estimate of each.



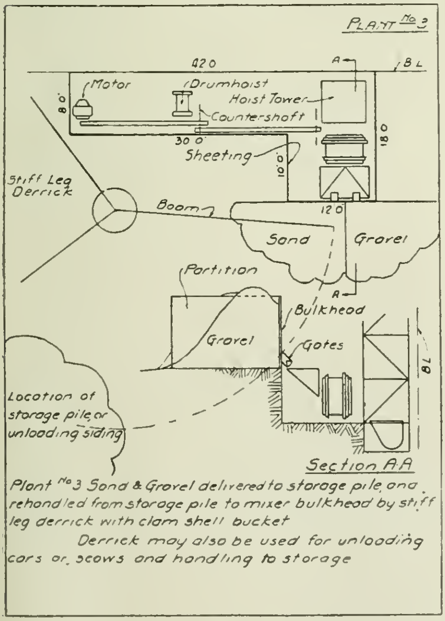
Plant No 1 Mixer in pit Sand & Gravel dumped on ground each side of mixer pit Mixer charged by hand using 6' carryalls

Fig. 1.



Plant No 2 Sand & Gravel dumped from back dump Motor Trucks against bulkhead at charging hopper Laborers will be required to trim material against bulkhead but wheeling is not required

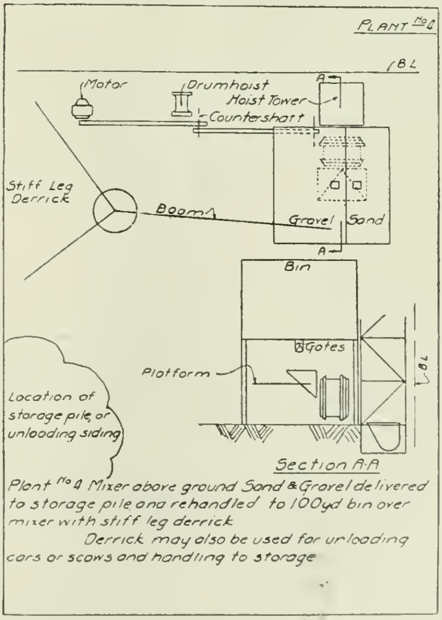
Fig. 2.



Plant No 3 Sand & Gravel delivered to storage pile and rehandled from storage pile to mixer bulkhead by stiff leg derrick with clam shell bucket

Derrick may also be used for unloading cars or scows and handling to storage

Fig. 3.

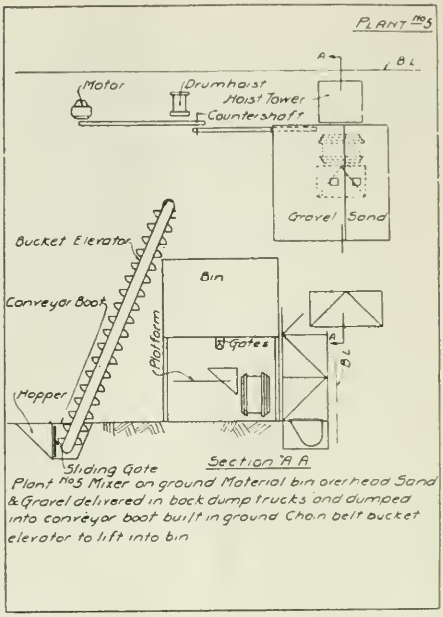


Plant No 4 Mixer above ground Sand & Gravel delivered to storage pile and rehandled to 100yd bin over mixer with stiff leg derrick

Derrick may also be used for unloading cars or scows and handling to storage

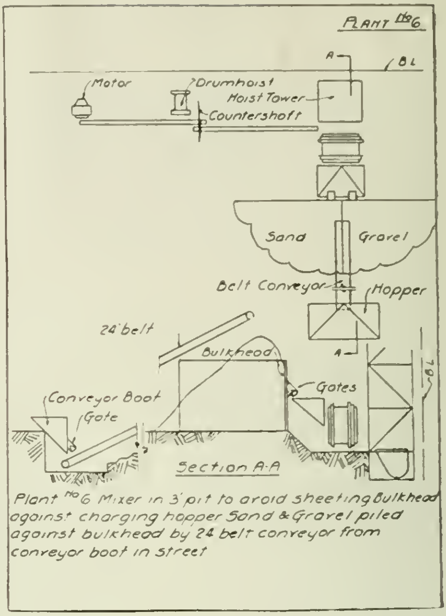
Fig. 4.

CONTRACTOR'S PLANT IN REINFORCED CONCRETE WORK.



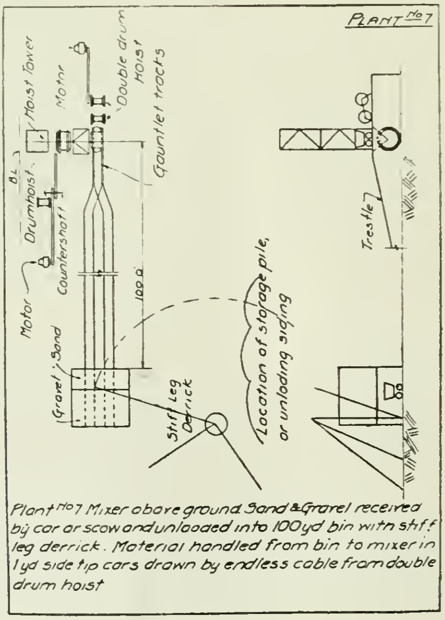
Plant No 5 Mixer on ground Material bin overhead Sand & Gravel delivered in back dump trucks and dumped into conveyor boot built in ground Chain belt bucket elevator to lift into bin

Fig. 5.



Plant No 6 Mixer in 3' pit to avoid sheeting Bulkhead against charging hopper Sand & Gravel piled against bulkhead by 24" belt conveyor from conveyor boot in street

Fig. 6.



Plant No 7 Mixer above ground Sand & Gravel received by car or scow and unloaded into 100 yd bin with stiff leg derrick. Material handled from bin to mixer in 1 yd side tip cars drawn by endless cable from double drum hoist

Fig. 7.

Contractor's Plant in Reinforced Concrete Construction.

Any contractor may plot for himself a similar set of curves, based upon his own layouts, by keeping a record of the cost of installation and dismantling each arrangement, and adding thereto his allowance for plant depreciation.

As plant obtained by a contractor on a rental basis will cost him more than the depreciation allowances made herein, such conditions must be taken into consideration in plotting similar charts and in estimating for jobs where it will be necessary to rent part of the equipment.

These charts are based upon depreciation in general, as per schedule attached herewith, which was considered suitable for jobs running from nine months to one year. For jobs of shorter duration these allowances would be slightly high. For the ¾ yd. plants depreciation has been taken at 60 per cent. of that for the larger plant.

Bucket elevator	40 per cent.
Carryalls	33 ,,
Concrete bucket	20 ,,
Hoists	20 ,,
Mixers	20 ,,
Motors	20 ,,
Side tip cars	20 ,,
Steel hoist tower	20 ,,
Stiff-leg derricks	20 ,,

Frame structures, such as bins, bulkhead, wood towers, etc., were considered a complete loss, owing to the uncertain salvage value of such material and the widely varying practices in regard to selling, storing, etc. Labour to dismantle will, in general, be found to offset any salvage.

An estimate of what is commonly called " cost of concrete " has been made of the labour required for the operation of each plant, mixing, hoisting and placing. This does not vary greatly for any given arrangement of plant, whether the job be 5,000 or 15,000 yds. per mixer. This labour unit, based on a labour rate of $6.50 per 8-hour day, has been added to the cost of plant and installations and when plotted graphically, a series of flat curves result. These curves as a rule are not parallel, the curves of the highest total cost at low yardages falling off most rapidly as the yardage increases. In the case of plant 6 and 3, it will be found that there is a difference of 60 c. per yd. in favour of plant 6 at 3,000 yds. and this is reduced to 9 c. at 15,000 yds.

To further analyse each arrangement, seven additional charts were prepared on which comparison was made between wheeling as a means of placing and chuting, using steel hoist tower, 50 ft. boom and counter-weight truss to eliminate wheeling on the floor. Charts were drawn as indicating yardages per mixer. When more than one mixer is to be used the charts should be consulted on the basis of yardage to be run by each mixer.

Conclusions.

A brief summary of the conclusions of the committee embodies the following recommendations. While no recommendations can be made for a standard plant layout to meet all conditions, the layouts which have been found best adapted to average concrete building construction can be classified as modifications of a few fundamental types.

The mere statement that it " saves labour " does not, under ordinary circumstances, justify the installation of an elaborate plant unless analysis shows that the saving in labour cost to operate is greater than the cost of the plant required to save that labour. To determine if this is so for any job, it is necessary to make for each layout under consideration a careful estimate of the cost of plant installation and operation per yard of concrete. This process of estimating may be simplified by the use of charts to be drawn up by the contractor, similar to the charts (seven such cost charts accompany the report) accompanying the report but based on the contractor's own record of cost for installation and operation and his depreciation and rental charges.

Then with these analyses in hand, it will be possible to make a comparison that will weigh the merits of each scheme from an operating standpoint and at the same time tell whether the proposed outlay for plant requirement under it is justified by the saving it offers.

Application of Metal Forms to Reinforced Concrete Construction.

This was merely a progress report and the subject is to be more thoroughly studied in the coming year. In the meantime the committee recommended the following points to manufacturers for their study and consideration :—

The forms should be of proper gauge to prevent sagging and bulging between yokes and stiffeners in order to overcome the unsightly condition usually found between column shafts and capital.

It is also suggested that where metal forms are used a saving could be effected by standardising the spans to multiples of one foot, taking up the over-run in inches equally in the two end bays of the building.

The standardisation might also be applied to diameters of depressed columns or panels.

The effect on the exterior treatment of concrete surface-paint or plaster of the oil used for greasing the forms, and which is not absorbed by the steel forms as it is by the wood, is mentioned as an interesting point for study.

CONCRETE OIL STORAGE TANKS.

In a discussion upon this question it was brought out that leakage was due to porosity or cracks caused by temperature variations. It was also stated that tanks made of rich concrete and lined with three or four coats of pure cement slush, allowing twenty-four hours between the application of coats, held gasoline without serious leakage.

One method described in making 150,000 gallon tanks was emphasised as *tank work*—not *concrete work*, it being important to appreciate the care necessary in operations. Towers and chutes were not used. The concrete was wheeled in barrows and tamped to prevent voids. Where voids were found, the surfaces surrounding were washed with muriatic acid before making the necessary patches. Where the concrete shrunk away from pipes passing through it a lead gasket in the form of the letter **S** was used to stop leakage.

In one case described, where a 3,000,000 gallon fuel oil tank was placed under ground, it was found that the leakage was due to the fact that oil followed the wire ties and horizontal joints.

The question of the proper design of tanks was mentioned with particular reference to the placing of temperature reinforcing in the top of the tank and the design to take care of the stresses as they occur. The use of gunite in making tanks was described with reference to various mixtures and coatings. While most of the gunite tanks were reported to be fuel oil tight, gasoline went right through, showing the necessity for some form of coating.

The tests of fuel oil tanks made by the Bureau of Standards were described in a paper by George A. Smith of the Bureau. The tanks were tested under varying heads, the top being made tight by means of gaskets made of imitation leather. Where hydrated lime was used to the extent of 5 per cent. to 10 per cent. it was found that lime did not help in the rich mixtures.

The fact was brought out that the effect of certain organic oils was greater than mineral oils on concrete. Cocoanut oil, neatsfoot oil and linseed oil were all found to have attacked the concrete. The tannic acid content of the oil is injurious to the concrete.

In the Bureau of Standards tests it was found that in spite of variations the results indicated that uncontrolled conditions had a great effect on the results. While a 1 : 1½ : 3 concrete well mixed and properly placed was considered allowable for use in tanks for some grades of fuel oil, the use of concrete tanks under ordinary conditions was not recommended for storage of kerosene and gasoline.

REINFORCED CONCRETE CHIMNEY CONSTRUCTION.

The report presented on this subject was referred back for further consideration owing to conflicting opinions. But it may be useful to state the three primary assumptions upon which the report was based and recommendations were made :—

Chimneys should invariably be of plain section, compression borne entirely by concrete, and tension resisted entirely by steel. Maximum tension in steel of 16,000 lb. per sq. in. was recommended and maximum compression in concrete of 400 lb. per sq. in. Shear in concrete should not exceed 40 lb. per sq. in. The question of wind pressure to be assumed in designing a chimney was recommended as 20 lb. per sq. ft. on the diametral area. The reinforcing recommended is wire mesh or expanded metal together with reinforcing rods. The matter of footings for the safe bearing power of the soil and materials in construction were considered and the type of forms to be used was left to the builder to produce a specified result.

SAFEGUARDS AGAINST FIRE HAZARDS.

This was the subject of a paper read by Mr. W. A. Hull, United States Bureau of Standards. The Barret fire, Frankford, U.S.A. was described, and reference was also made to the Far Rockaway fire.

These were two cases where although the buildings were what might be described of modern design and built in accordance with the best practice, they yet failed to offer resistance when attacked by fire.

The cause of the failure is identical in both cases, namely the use of an unsuitable aggregate.

It is pointed out in the report that while concrete gives the best fire resistance of any structural material, special hazards require special treatment.

In the final summing up the recommendations state that :—

It is now a well-established fact that round columns are safer than square ones, other things being equal where there is a danger of spalling. Therefore, where the fire hazard is shown to be unusually great it is only reasonable that the columns should be round. It appears reasonable to expect that a flat slab will fare better with a fire than a deep girder. Where this type of floor or roof can be used to advantage, considerations of fire-resistance favour using it. Limestone, either crushed or in the form of limestone gravel, as well as trap rock, are all so definitely superior to siliceous gravels, crushed sandstone and crushed granite as to make two distinct classes of aggregate which for brevity are called spalling and non-spalling. Where the cost of non-spalling aggregate is excessive, the fire hazards can be met by the use of secondary reinforcement in the concrete together with a reasonable increase of the thickness of the protecting coat. The effectiveness of secondary reinforcement in the form of light grade of expanded metal placed in the protective concrete has been tried out in fire tests of full size building columns with promising results. There appears to be no reason for doubting that the fire resistance of girders and slabs made from the spalling types of aggregate should be brought up to any reasonable standard by the proper use of secondary reinforcement with protective concrete of suitable thickness.

CONCRETE FLOOR FINISH.

In discussing the unmerited condemnation of cement finished floors the committee states that the discomfort which leads to the objection by highly paid help to the hardness of the surface is probably due to the fact that the temperature of cement finished floor is usually considerably less than the body temperature, thus accentuating the natural complaint as to hardness. Conditions as to money and time available for ordinary commercial structures as usually built prevents carrying out provisions for insuring proper floors. It should be urged upon architects, engineers and owners that an ultimate financial gain is possible for the owner if the necessary precautions are taken with the original floor installation. A surface constructed according to the best recommended practice, while costing more at first will give good service, but a poor floor will no doubt at once call for the application of a liquid hardener, paint or other remedy, and in the course of one to five years will have to have a renewed surface which will make the final cost per year for the poor floor finish much greater than for an original good finish.

The loss in time of the use of the building for a period of two weeks to one month which should be ample for proper application and curing will be offset by the value of the increase in wearing quality, and the inconvenience arising from the interruption of operation while the floors are being treated or defective surfaces replaced will be dispensed with.

Certain fundamental requirements for good cement finish floors are outlined as follows :

1. *Proper workmanship.*—Skilled help is an indispensable requisite and sufficient time should be left in order to allow the proper manipulation.
2. *Proper consistency of mortar.*—Mortar should be mixed and placed in as dry a condition as possible still to allow for the manipulation of the surface. Tamping should be resorted to in order to bring the excess water to the top.
3. *Proper selection and grading of aggregates.*—The aggregates available at permissible cost control in this respect. Careful study should be made of the wearing qualities of the aggregates available in the vicinity of the work. It will often be found that the slightly increased cost for aggregates brought from a distance will be many times repaid in the better wearing qualities of the floors produced.
4. *Proper protection and curing for finished surfaces.*—All classes of finishes from which wear is expected should be protected for at least ten days. This adds at least 50 per cent. of resistance to wear over an unprotected surface and, if conditions permit, another ten days should be allowed for this purpose.

Amongst other reports presented was one on concrete products, and on the surface treatment of concrete ; and tentative recommendations were made in regard to Concrete House Construction. The question of roads received much attention. The report on colouring concrete contained nothing new but was a useful summary of present practice.

MEMORANDUM.

Bridges with Floors below Water Level.—To utilise the Manistique River for operating pulp and paper mills its channel through the city of Manistique has been converted into a power canal of trough section, with concrete walls having exterior buttresses. This canal is nearly a mile in length and is closed by a concrete dam 360 ft. long. Two bridges cross the river, and their floors were lower than the new elevation of the water as raised by the dam. As it was very undesirable to raise the bridges, they were replaced by concrete structures under which the water is syphoned, the underside of the bridge being rough shaped in cross section so as to facilitate the flow of water. The parapet walls, therefore, are the sides of a great rectangular concrete channel, the bottom of which is the floor of the bridge, the water level against the parapets being 3 ft. above the floor of the highway bridge and 6 ft. above that of the railway bridge. These bridges are about 300 ft. long, but the special construction is required only for the 160 ft. width of the canal or river. Waste gates in the side of the canal provide for carrying off excess flow in case of flood. With a working head of 25 ft. the turbines develop about 8,500 horse-power, all of which is utilised in the mills for making paper for newspaper work, with a production of about 100 tons daily.—*The Engineer.*

CONCRETE IN THEORY — AND PRACTICE. —

A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.

REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—Ed.

As regards choice of stone, brick, etc., for aggregate for concrete, the following considerations apply.

The ideal material will have very great strength and a rough surface (so that particles adhere better to the mortar, and do not so readily exert a splitting tendency when the concrete is compressed). It will be impervious to air and water, not only because it then protects the steel much better from corrosion, and prevents deleterious chemicals from reaching the interior of the concrete, but also because a non-absorbent material shrinks less when the concrete dries out, and, therefore, is less liable to produce objectionable shrinkage cracks in the concrete. It will not contain chemicals which will react with those in the concrete to its detriment, or with substances in which the concrete may come into contact.

Probably the material which most nearly complies with these is a good rough *granite*. In many districts this is expensive.

Perhaps the next best is *flint* or *shingle*. This is sometimes found on the beach or in pits in the desired size. In other cases, it requires to be crushed. The crushed particles tend to form very smooth-sided wedge-shaped particles which much reduce the strength of the concrete by causing splitting. The rounded particles are for this reason to be preferred.

When obtained from pits, it generally requires to be washed, to remove all loam. The trace of salt water from beach does not matter for outside work, but may remain sticky if for inside work.

Ham River grit is a crushed and washed pit shingle and is probably the best material readily obtained in London.

Broken Brick often makes quite a strong concrete, but it has its dangers. Fletton bricks are salted and deleterious to concrete. Lime mortar insufficiently carbonated is also a danger in concrete, therefore the bricks must be carefully cleaned. The dust produced in crushing is quite a good material instead of sand when it can be guaranteed free from lime, etc., but as lime in mortar is generally crushed into the dust, it is safer not to use this, but to mix sand with the screened material.

A concrete made with crushed brick shrinks much more than a ballast or granite concrete when it dries out, therefore when used in floors, etc., these are likely to show contraction cracks. For foundation work this does not, as a rule, matter so much.

Brick concrete is not suitable for tanks or reservoirs, or for piles, etc., in water.

On the other hand, broken brick is much the best material where fire resistance is important. Having been burnt once, ordinary fires may be said to leave it cold.

On the other hand, granites and shingles generally split very badly under fire and are much more quickly destroyed.

The author has made exceptionally strong concrete from crushed firebrick from old retorts, which would obviously stand fire excellently.

Coke Breeze, Cinders and Clinkers have the attractive qualities of making very cheap concrete, and of making a concrete much lighter than usual (down to 75 lb. a cu. ft. instead of 150) and one into which a nail can be driven, and which will hold it.

They are much used for partition blocks and fixing bricks, for securing door frames and window frames to.

The strength of concrete made with these materials is much inferior to that of good ballast concrete, and the author would never use such materials for reinforced concrete. Apart from the great porosity of the concrete, which therefore protects the steel from corrosion but poorly, there is always a certain risk of the aggregate containing sulphur and causing total destruction of the concrete by expansion. The author knows one case where a floor 15 ft. span had expanded seven inches in one year owing to sulphur in the clinkers, pushing the walls over so far that they had to be rebuilt. He also knows of many cases of roofs which have caused endless trouble due to the use of this material. It is true that it has often been successfully used, but only at great risk.

Slag often makes a hard, strong concrete, and the rough surface it provides greatly increases the adhesion with the mortar.

Contamination with sulphur often makes it dangerous, as explained above.

Limestone is much used in America, but varies so much in different districts that no general rule can be given. It is often porous, absorbent, and very susceptible to fire.

Sandstone also varies greatly. Some samples have great strength and give a strong concrete though rather porous for water work. Other samples are too friable.

Concrete Mixing.—For reinforced work, the concrete must be specially well mixed, as one bad patch may ruin a beam or column, and the extra richness of another patch, owing to its having the cement that should have gone to the bad patch, does nothing to prevent disaster.

When hand mixing is employed, the materials are carefully measured out in *gauge boxes*, screeded off level with the top of the box, and then mixed by shovelling over three times dry.

Much skill can be put into the handling of the shovel during this work with a view to obtaining uniform distribution of cement. Water is then added by a hose or watering-can with a rose, while it is turned over three further times wet. A minimum of water must be used consistent with efficient placing round all bars and filling up all corners. The whole mixing process is best done on a well-made, smooth banker board about 8 ft. square, or on a smooth concrete floor. The concrete should have an even colour when mixed.

Good machine mixing is better than hand mixing, and therefore it is advisable to add 10 per cent. more cement with hand mixing.

Concrete mixing machines vary greatly in design. Some accept a definite charge of measured materials, and turn them over first dry, and then wet, water being admitted when the mixing is half done. Such machines are called *batch mixers*. Others receive a continuous stream of the different ingredients through orifices, and are called *continuous mixers*.

Of the two, the former are greatly to be preferred. The continuous mixer often leads to bad proportioning of concrete.

The amount of material passing through the orifice depends greatly on the wetness of the mixture. When the sand is dry it will flow through readily and in a given time much passes. When it is wet, it clogs and less passes in a given time. Consequently the proportions vary considerably from day to day, as the author has personally experienced.

MEMORANDUM.

Protection for Reinforced Concrete against Electrolysis.—The Committee on Electricity of the American Railway Engineering Association report that a waterproof shell protecting the concrete structure is the most plausible form of protection of reinforced concrete against electrolysis, because it not only protects the reinforcing bars from moisture and later oxidation, but also protects the concrete surrounding the rods from abrasion and, eventually, exposure of the iron. Last year it was suggested that the following methods be considered: (1) Use of copper-plated reinforcing bars; (2) Introduction of reinforcing bars made of copper alloy; (3) Reinforcing bars surrounded by rough insulating enamel impervious to salt water and moisture; (4) Waterproof plastic layer of material with petroleum asphalt base, or some established waterproofing material free from electrolytes, surrounding base of concrete. Further studies have led to the conclusion that the first three methods proposed are not practical because of high cost.

The fourth method is recommended, but attention is called to the necessity of using the proper waterproofing material on the inside of the protecting shell. The waterproofing pitch should remain flexible for an indefinite time; should have a melting point in the neighbourhood of 200° F., and be elastic in stretch at least ½ in. at a temperature below freezing and have approximately an inch stretch at 60° F. If the pull is gradually applied, the stretch should be approximately 6 to 7 in. at 60°.

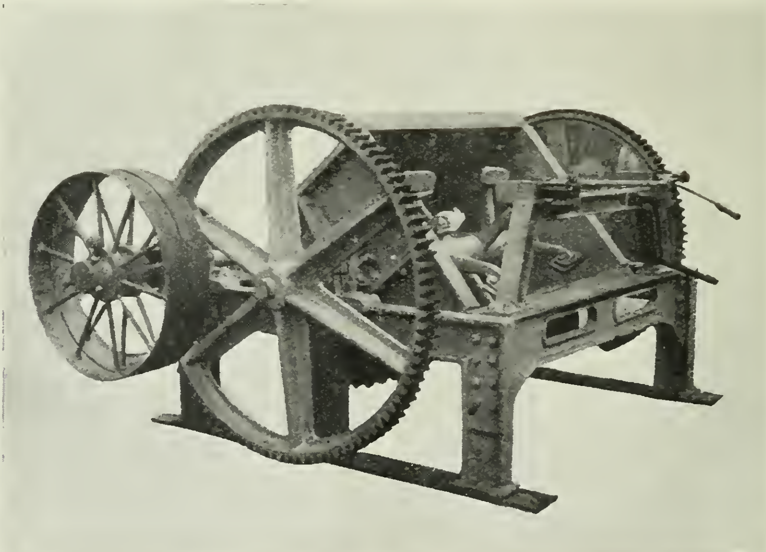
Asphaltic petroleum pitch is soluble in gasoline, which is likely to be present in city sewerage, but recent experiments show an elastic waterproofing pitch may be made from coal tar that is insoluble in gasoline but retains all of the characteristics of the asphaltic petroleum pitch.

It is necessary to protect with waterproof pitch the top or other exposed portions of concrete structures, as well as the sides, to prevent penetration of salt air or moisture.—*Engineering News-Record.*

A NEW METHOD OF CONCRETE MIXING.

A REPRESENTATIVE of CONCRETE AND CONSTRUCTIONAL ENGINEERING recently had the opportunity of inspecting a special method of concrete mixing now being carried out in connection with the buildings at present being erected in Old Street, London, for Messrs. Charles Churchill & Company, Ltd., Machinery Manufacturers, by Messrs. Holland & Hannen and Cubitts, Ltd. In this method, the details of which were worked out by Mr. H. T. Desch of the last-named firm, a machine is being employed which, though little known, has been in successful use for some years, but has not so far been put upon the market.

THE MACHINE.—This is electrically driven and is of the type in which the blades revolve and not the drum. The blades, 16 in number, fastened at the ends of arms, are placed at such an angle that the material is propelled, during mixing, from side to centre and *vice versa*, and since the blades, during their revolution, pass within half an inch of the interior surface of the drum, the latter does not become clogged—indeed, after the mixture has been discharged, the surface is practically clean. The " drum " is really a half cylinder, open at the top, so that the mix is in view the whole time.



THE METHOD OF MIXING.—This work has been well thought out and is well organised. There is a large platform in which is formed a hopper with sloping sides placed centrally over the " drum." The aggregate is arranged in heaps, the coarse on one side and the fine on the other. The cement shed is arranged for easy access. Measuring boxes without top or bottom, and of carefully calculated dimensions, are placed close to the hopper on the mixing platform, that for the coarse material on one side and that for the sand on the other. These are filled and levelled off, the coarse aggregate being equal to five parts by volume and the fine 2½ parts. The contents of a bag containing 100 lb. net of cement is tipped on the sand. The cement being taken as weighing 90 lb. per foot cube the total volume of the dry materials in the batch for the proportions 1 : 2½ : 5 is 9·5 cubic feet. The sand box is lifted and the sand with the cement which has been tipped over it is shovelled into the mixer, the blades of which are still rotating. These materials are mixed dry for 15 seconds, time sufficient to produce a mixture of uniform colour. The measured quantity of coarse material is then shovelled into the mixer. At the moment the coarse material begins to fall into the drum a spray of water is turned on from a pipe; this pipe extends the whole length of the drum so that the water is applied evenly, as through a rose, over the entire surface of the mixture. The quantity of water is not measured but (and this is part of Mr. Desch's system) is left to the discretion of the workman operating the machine, who varies it according to the nature of the aggregate, atmospheric conditions and other factors, until that consistency is reached which his experience tells him is correct. This is the only human element which enters into the method, and with an experienced and reliable man has the advantage over absolutely mechanical mixing in that a measured quantity of water under certain circumstances is sometimes excessive and under others insufficient.

The total time occupied by the whole operation of mixing and discharging including the 15 seconds dry mixing, is three minutes, the resulting mix being uniform in colour, as is the finished work. Twenty batches of perfectly mixed concrete can be obtained by the use of this machine in one hour.

Placing the Concrete.—The mixer discharges into a skip which travels on rails to the foot of a hoist running in a wooden frame. Upon reaching the floor upon which the concrete is to be deposited, a further set of rails enables the skip to be run to the site of the work in progress. Here the material is placed in position and tamped.

This system seems to be fully justified by the results, some of which appear to be remarkable as far as density and strength are concerned, walls and floors when struck with a hammer or pickaxe giving every evidence of being specially sound and hard. Another feature of the method is the economy of labour. One illustration of this is the ease with which the proportioning of the material and the filling of the mixer is done; the work proceeds regularly with the minimum of effort on the part of the men.

MEMORANDUM.

Industrial Standarisation of Engineering and Allied Products.—A Conference, unofficial in character, of the Secretaries of the various Standardising organisations at present in existence has recently been held in London. The Conference was convened by the Secretary with the cordial permission of the Main Committee of the British Engineering Standards Association, and was opened by the Chairman of the Association, Sir Archibald Denny, Bart.

The following countries were represented by secretaries: United States (Dr. P. G. Agnew); Norway (Mr. A. Eriksen); Holland (Mr. E. Hijmans); Canada (Mr. J. R. Durley); Belgium (M. G. Gerard); Switzerland (M. Zollinger); and Great Britain (Mr. C. le Maistre, C.B.E.).

The object of the Conference was the exchange of ideas looking towards the establishment of closer relationship. It is interesting to note that, in most countries, it is becoming more and more recognised that industrial Standardisation—whether of quality or dimensions—to be really useful must be arrived at through a process of unifying the needs of industry. It also appears that whereas engineers are everywhere giving freely of their time and experience to this important work, its value to commerce generally is far too little appreciated, and is therefore not being supported financially as well as it should be.

There are some who think that the time has arrived to create an International organisation for standardising all engineering products, but the Conference as a whole inclined towards the development of International Standardisation along national lines, and sectionally, similar to those adopted by some other industries.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Masonry Structures. By Frederick P. Spalding, Professor of Civil Engineering, University of Missouri.

Chapman & Hall. Price 21*s*. net.

In this book, the word "masonry" is used in its most inclusive sense as including stone, brick, building blocks of clay and shale, sand lime and concrete, terra-cotta construction and hollow tiles, plain concrete and reinforced concrete. We in this country would perhaps hardly have described concrete and reinforced concrete as masonry, and concrete foundations and brickwork would also probably not be generally included under this term. It is well to make this clear, because otherwise a wrong impression might well be given as to the extent of the subject-matter covered by the book.

The chapter on stone masonry includes description and analysis of various kinds of stone together with figures in regard to strength, modulus of elasticity and so on, and the illustrations of stone working tools and the descriptions of various stone finishings are clear.

A good feature in the book is that the question of cost receives attention in regard to the various materials considered. It will, however, be apparent to the reader that this section of the book quite obviously refers to American conditions and can have little application to conditions prevailing in Europe.

The portion devoted to reinforced concrete is clear, but does not present any outstanding features. The question of the yielding of concrete does not appear to be referred to. The rest of the book is given up to a study of compressions and stability of retaining walls of various kinds, masonry dams and bridges of concrete and masonry, and lastly to culverts, conduits and foundations. While the work is not one marking any outstanding advances on existing books covering the same ground, it is clearly written and well produced, and may be thoroughly recommended.

Engineering Construction. By W. H. Warren, LL.D.

Longmans, Green & Co. Vol. I., 30*s*. net. Vol. II., 36*s*. net.

Vol. I. Steel and Timber.

This volume is the third edition of a book first published in 1894, which has, however, been added to in both the subsequent editions. The book combines in an excellent manner discourses on the properties of the materials, including detailed tests both of plain specimens and of built-up structures, a clear and concise exposition of the fundamental laws of mechanics on which structural design is based, and examples taken from practical work.

The book starts with an explanation of stress, strain, elasticity, repetitive tests, properties of cast iron and steel, determination of safe working loads and structures. This is followed by a chapter on timber, giving not only strengths tested in various ways and for many different descriptions of timber, but also notes on the seasoning, relative combustibility, and notes on the preservation. The next chapter is devoted to graphical methods of calculation, and Chapter 4 to shear stress, bending moments, and influence lines, while Chapter 5 deals with moments of resistance, and resistance to shearing stress.

The rest of the book is devoted to discourse on actual structures, such as bridges and viaducts, timber pile bridges, roofs, lattice girders, bowstring girders, continuous girders, and cantilever bridges, strength of columns, notes on riveted joints, and joints in timber structures, water pressure and its effect on structures, and stresses due to curvature and the use of bricks on bridges and viaducts, stresses in braced piers, weights of girders and trusses, live loads on bridges, plate girder bridges, Pratt truss bridges, Parker truss bridges, swing bridges, arched and suspension bridges.

It will be seen from the above that the book covers a large range of engineering structures, and containing, as it does, 475 pages with an almost equal number of figures with the matter carefully chosen, it covers the ground in an excellent manner. The book is one for the advanced engineer with considerable facility in mathematical symbols and can be thoroughly recommended.

Vol. II. Masonry and Concrete.

This book begins with an exposition of stresses in blocks of masonry, principal planes, and principal stresses, which is probably as clear as these rather difficult problems can be made. The author then proceeds to give considerations for stability of retaining walls including surcharged and inclined walls. In this discussion we notice that the author holds that Rankine's theory gives results erring on the full side owing to neglect of the friction between the earth and back of the wall. Mr. J. C. Meen's theory of earth pressure is fully described and the stresses on sheet piling acting as a retaining wall. The usual description of the manufacture of Portland cement and the testing thereof is then given, and is followed by an article on brickwork in which the author's tests on the subject find a well-deserved place. A chapter on building stones and concrete pipes follows, after which the book is devoted to concrete, both plain and reinforced. The treatment follows that of most American books on the subject in giving outstanding attention to retaining walls, high masonry dams and arches, and comparatively little attention to the application to buildings, bending moments in beams and columns, and so on. We miss particularly any reference to the yielding of concrete under stress with time and the very large effect this has on the distribution of stresses between steel and concrete, the author being apparently content to accept the modulus of elasticity as given by many experimenters as a result of short time tests, and to ignore the fact that in the course of a year or two the actual deformation may be six or seven times as great at the distribution of stresses as between the steel and concrete radically different.

While we know of books which we prefer on the subject of the application of reinforced concrete to buildings, the treatment on bridges, masonry dams, and retaining walls is very full and helpful, and the volume will undoubtedly find a place in the bookshelves of fully qualified engineers specialising in these subjects.

MAKING MOULDS OF PLASTER, ETC.

Das Gipsformen. {By Dr. A. Moye. Verlag der Tonindustrie Zeitung.

Berlin: 1921. 37 pages. Price 6 Marks.

Although there are several books in the English language which deal with the moulding of articles by means of plaster, wax, etc., a new edition of Dr. Moye's volume will be welcomed by those interested in the subject who can read German with sufficient fluency.

The use of plaster and other materials as a means of duplicating objects by moulding has gained, rather than lost, importance during the last few years, and this small pamphlet covers the ground with sufficient completeness to be really useful.

So far as most readers of *Concrete and Constructional Engineering* are concerned, the most interesting section is that dealing with moulding articles of cement, or rather of a mixture of cement with twice its weight of sand and just sufficient water to produce a paste of the requisite consistency. Moulds made of glue or plaster and varnished internally are recommended, but the difficulties experienced—especially in the production of hollow-ware—whilst suggested are not explained, nor are sufficient details given to make the book of use to the novice.

MEMORANDUM.

Wages Reductions.—Two important agreements affecting the building and allied industries were reached last month by representatives of the employers and operatives concerned. The National Wages and Conditions Council for the Building Industry agreed that the wages of all operatives employed on building works should be reduced by 2*d*. per hour, as from May 16 (making the rate 2*s*. 2*d*. per hour for skilled men and 1*s*. 11*d*. for labourers in grade A towns, with proportionate reductions in other areas), and that the labourers' wage should be reduced by a further 1*d*. per hour as from July 1. The Public Works Conciliation Board agreed that the rate of wages paid under Schedule X to operatives engaged on public works should be reduced from 1*s*. 11*d*. to 1*s*. 9*d*. per hour as from the first pay-day after May 10.

CEMENT NOTES.

By Our Special Contributor.

Cement Grout.

THE value of Portland Cement in the form of "grout" for filling up bolt holes in foundation beds and for fixing machinery on concrete or brickwork foundations has been known and appreciated for many years, but the use of grout in large quantities at a time for the consolidation of subsoil or ancient foundations therein is of comparatively recent date. When the insecurity of the foundations of Winchester Cathedral threatened the stability of the building, a remedy was found in forcing large quantities of cement grout underneath, and into, the foundations. An even more extensive use for grout is exhibited by the "cementation process" adopted for the sinking of colliery shafts, the consolidation of the ground and the prevention of flooding by water being attained by the method of forcing cement grout into the earth under high pressure.

Experience among the users of cement grout suggests that there is some misapprehension as to the qualities of this material, and the writer has known an engineer to be greatly disturbed because after mixing cement with an equal volume of water in a pail he was confronted the next morning, not with the hard block he expected, but with something hardly better than mud.

To produce a cement grout that will flow down a long hole or pipe of say 2 inches diameter, it is necessary to mix cement with at least 50 per cent. of water, and in this state of dilution it is unreasonable to expect a hard mass. The successful application of grout depends upon the removal of the excess of water, and this occurs in most cases by absorption by the surrounding concrete, brickwork or strata with which the grout comes in contact. Unless the excess of water is removed, the grout cannot become a really hard material.

This point can be illustrated by pouring cement grout into two briquette testing moulds, one of which should stand on an iron plate in the usual manner, and the other on a blotting pad or other absorbent material. When the two briquettes are put in the testing machine at the expiration of seven days, it will be found that the briquette made on the iron plate will give a result of less than 200 lb. per square inch, while that made on the absorbent base will attain a strength of 500 lb. or more, approaching, in fact, the normal tensile strength of the cement.

The Colour of Portland Cement.

THERE are four factors which influence the colour of Portland cement, viz., the proportion of iron the Cement contains, the type of kiln in which it was calcined, the fuel used to calcine it and the degree of calcination.

Dealing with these in order, the iron in cement is, of course, derived from the raw materials used in its production. A cement containing about one half per cent. or less of iron oxide will be white, and with increasing proportions of iron oxide up to 5 per cent., which is about the maximum in commercial cements, the cement passes from light grey to dark grey with a tinge of brown. Iron oxide has no influence on quality, so that the light grey colour due to lack of iron does not imply inferior quality nor does the dark colour denote good quality.

There are two principal types of kiln in which cement is calcined, viz., rotary kilns, where the material is heated with a flame produced from powdered coal and in which the material does not come into contact with the fuel; and fixed kilns, into which the raw material and the fuel are loaded together and come into intimate contact. The contact between material and fuel appears to have a considerable influence on the colour of the cement, because identical raw material fed into rotary and fixed kilns respectively will produce dark coloured cement in the former case and light coloured in the latter case, although at the same time there would be no essential difference in the quality of the two cements. Here again, then, colour does not indicate the quality of cement.

It is the practice of some cement manufacturers to use anthracite fuel for calcination in rotary kilns, and where this is done, the resulting cement is frequently brown in colour. This characteristic is confined to the dry cement, the colour of the set cement being normal. Numerous tests of such brown cement go to show that the quality is in no way affected by the anthracite fuel and the brown colour it produces.

Finally, when a cement is underburnt, its colour may be light grey, light brown or yellow, and in this case the colour *does* indicate defective quality.

It will thus be seen that the colour of cement is no guide to its quality, because out of four possible causes affecting the colour, three have no relation to quality. If any abnormality in colour is due to underburning, the defective quality would then be revealed in the soundness, strength or chemical composition of the cement, and all these features can be ascertained by the application of the standard tests.

QUESTIONS AND ANSWERS RELATING TO CONCRETE.

Question.—E. A. O. writes :—Could you please give me some information as to the standard required in the compulsory subjects and Hydraulics and Surveying of Part I of the Concrete Institute examination? Are copies of the previous examination papers procurable? If it is possible, I should like a list of books that would cover the necessary ground of the above subjects.

Answer.—The Standard required for Part I of the Concrete Institute examination can only be intimated from the *portions* of the Syllabus * to which attention is now drawn :—

Part I. (A) Compulsory Subjects.

1. Principles of Statics and Theory of Structures.—Forces acting on a rigid body ; composition and resolution of forces ; couples ; moments of forces ; conditions of equilibrium, with application to loaded structures. Graphical and analytical treatment of the foregoing. Centre of gravity ; specific gravity.

Graphic and analytic methods for the calculation of bending moments, shearing forces, and the stresses in individual members of framed structures loaded at the joints ; reciprocal diagrams ; incomplete frames and redundant members ; buckling of struts ; effect of different end fastenings on their resistance ; combined stresses ; section modulus ; methods of dealing with statically indeterminate problems as beams supported at three points, etc. ; travelling loads ; rigid and hinged arches ; stresses due to weight of structures ; theory of earth pressure and of foundations ; stability of masonry and brickwork structures.

2. Strength and Elasticity of Materials.—Physical properties and elastic constants of cast iron, wrought iron, steel, timber, stone, concrete, cement and other materials ; relation of stress and strain ; limit of elasticity ; yield point ; Young's modulus ; coefficient of rigidity ; extension and lateral contraction ; resistance within the elastic limit in tension, compression, shear and torsion ; strength and deflection in simple cases of bending ; beams of uniform resistance ; reinforced concrete beams.

Ultimate strength with different modes of loading ; plasticity and permanent set ; working stress ; phenomena in an ordinary tensile test ; stress-strain diagrams ; suddenly applied and impulsive loads ; resilience ; fatigue of metals ; effects of hardening, tempering and annealing.

Forms and arrangements of testing machines for tension, compression, torsion and bending tests ; instruments for measuring extension, compression and twist ; forms of test-pieces and arrangements for holding them ; methods of ordinary commercial testing ; percentage of elongation and contraction of area ; test conditions in specifications for the principal materials of construction.

Part I. (B) Selective Subjects.

5. Hydraulics. Pressure on surfaces ; centre of pressure ; strength and stability of structures supporting water pressure ; laws of fluid friction ; impact of water on surfaces ; storage of water and construction of reservoirs.

7. Geodesy. The theory of structure and adjustment of the principal surveying and levelling instruments, and the principles of their employment under various conditions ; land surveying ; levelling and use of theodolite.

For a pass, a minimum of half marks must be obtained.

For copies of previous exam. papers apply to Sec. Concrete Institute, Denison House, 296 Vauxhall Bridge Rd., S.W.1.

The Institute does not at present recommend a list of books for study.

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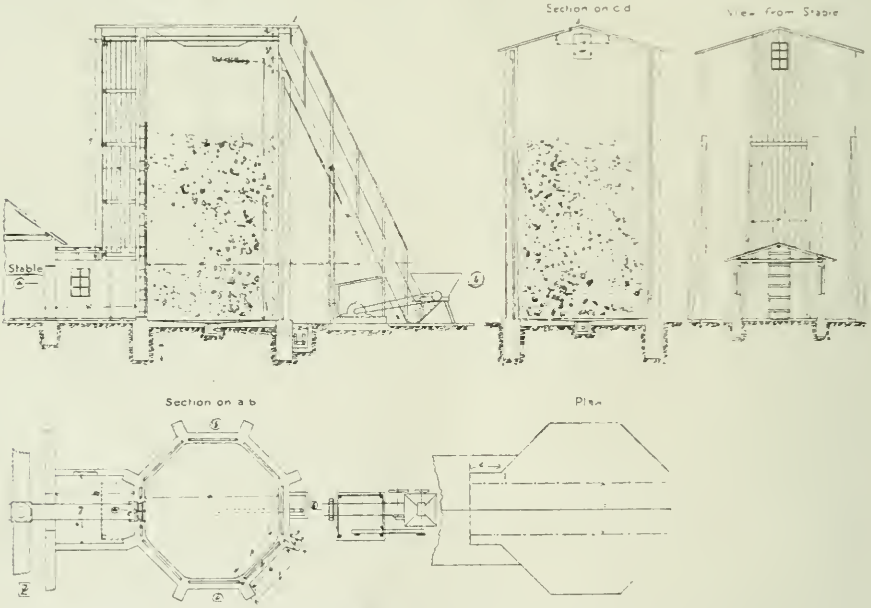
* Note :—We propose publishing the complete examination syllabus in a subsequent issue.

SOME ABSTRACTS FROM THE FOREIGN PRESS.

Agricultural Silos.—For ordinary purposes, a silo should be of such a size that 1,280 cub. in. of ensilage can be allowed daily for each head of cattle. Hence, for fifty cattle there should be a daily allowance of 64,000 cub. in., and allowing an internal diameter of 15 ft., the silo would have to be at least 24 ft. high internally in order to provide ensilage for 150 days. About 10 ft. additional height would actually be necessary as space must be left for an upper window or entrance, etc.

The walls of the silo should be watertight and sufficiently strong to withstand the pressure of the ensilage which may be taken as equal to water. In cold countries, the walls must also be thick enough not to allow too much loss of heat by radiation, as ensilage which has been frozen soon decomposes when it again reaches normal temperature. The outlet through which the ensilage is withdrawn should be so placed that the internal pressure of the contents of the silo is radial and tangential to the doorway. The latter is seldom more than 2 ft. wide and it must be so constructed as to resist the pressure to which it is subjected. The door must fit tightly as it is essential to prevent the undue admission of air through. A good drainage system is also desirable and a large tap at the bottom of the silo is useful.

In a well-built silo only 5–8 per cent. of the nutriment in the original grass is lost, whereas by any other method of storage there is a loss of 30–50 per cent. and the substitution of moist ensilage for dry hay increases the production of milk in the winter months. For this reason, it is estimated that under present conditions, a silo can be built at such a price that it will repay for itself at 10 per cent. compound interest in five years.—*Zement.*



The German Concrete Association.—The twenty-fourth Annual Meeting of the German Concrete Association in March last was well attended. The Secretary's report shows that the Association has continued its well-known activities, especially with respect to the publication of technical papers. There has been exceptional activity on the legal side since the judiciary powers of the Association were made effective.

The Association has made special efforts to provide teaching material for building students, including plans—some with full details—lantern slides, models and even small buildings, and members are invited to contribute further information, models, etc., for the use of students.

The meetings of the various sections followed and were well attended, but the subjects discussed do not call for any special comment.

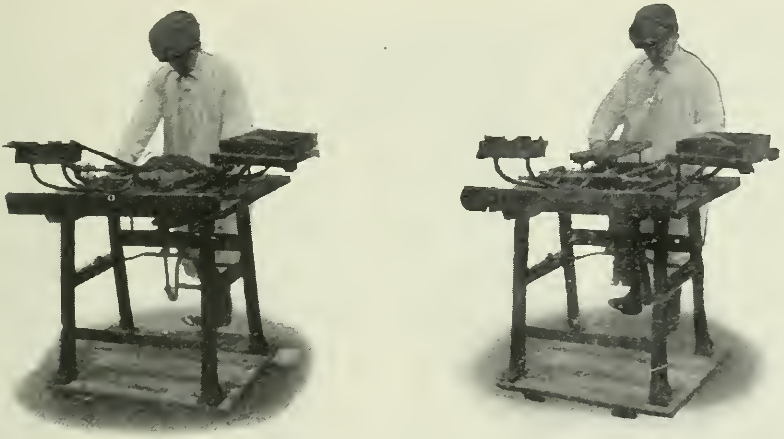
INDUSTRIAL NOTE.

CONCRETE ROOFING TILES.

A NUMBER of ex-officers have recently started works at Iver, Bucks, for the manufacture of concrete tiles, the works being situated on the banks of the Grand Junction Canal.

The manufacture of concrete tiles is comparatively a new industry as far as England is concerned, where it has only been in existence for about thirteen years, but there is a growing demand for these tiles, especially in connection with the various housing schemes. On the Continent, however, the industry has been in existence for a considerable period, and roofs fifty or sixty years old are to be found there in excellent condition, little or no repairs having been needed.

The Express Guaranteed Corporation, Ltd., which is the title under which these ex-officers have established their firm, use only the best materials for their work. The sand employed is sharp and well graded, having only 30 per cent. of voids, and is doubly washed before use.. The Portland Cement is supplied by the Cement Marketing Company and the mixture used is 1 to 3 (it will be observed the amount of cement used is nearly sufficient to completely fill the voids in the sand). The materials are carefully measured and thoroughly incorporated in a mechanical mixer.



THE MACHINE ON WHICH THE TILES ARE MADE.

The colour of the tiles is red ; this colour is ground up with neat Portland Cement in a grinding machine and is applied to, and thoroughly incorporated with, the surface of the tile during manufacture, and it is this coating that makes the tile impermeable even when the voids in the sand are 40 per cent. or over.

The shade is varied daily, so as to produce on a roof the mottled appearance of clay tiles. The surface is rough finished, so that it may " weather," but not to the extent of a clay tile, which in London becomes indistinguishable from a blue slate.

After 42 days the tiles are sufficiently strong for transport and handling, and it is at this age that they are sold, but they are then only at about half their ultimate strength. At 90 days they have acquired the greater part of their strength, which, however, will continue to increase over a considerable period. A Vickers machine is used for the making of the tiles.

Fixing.—The tile, like the " Bridgewater " tile, has lugs which are fitted and hooked over battens placed 13 in. apart and interlocks along the edges. The rows must break joint and special half tiles are made for this purpose. The eaves batten must be an extra 1 in. in depth so as to give the same tilt to the bottom row of tiles as to the rows above. For hips and valleys the tiles are easily shaped by nipping off the unrequired portion with a pair of pincers.

The advantages claimed for these tiles are :—

1. Their weight per square of roofing is only 7 cwt., thus reducing the cost of transport and allowing of lighter roof scantlings.

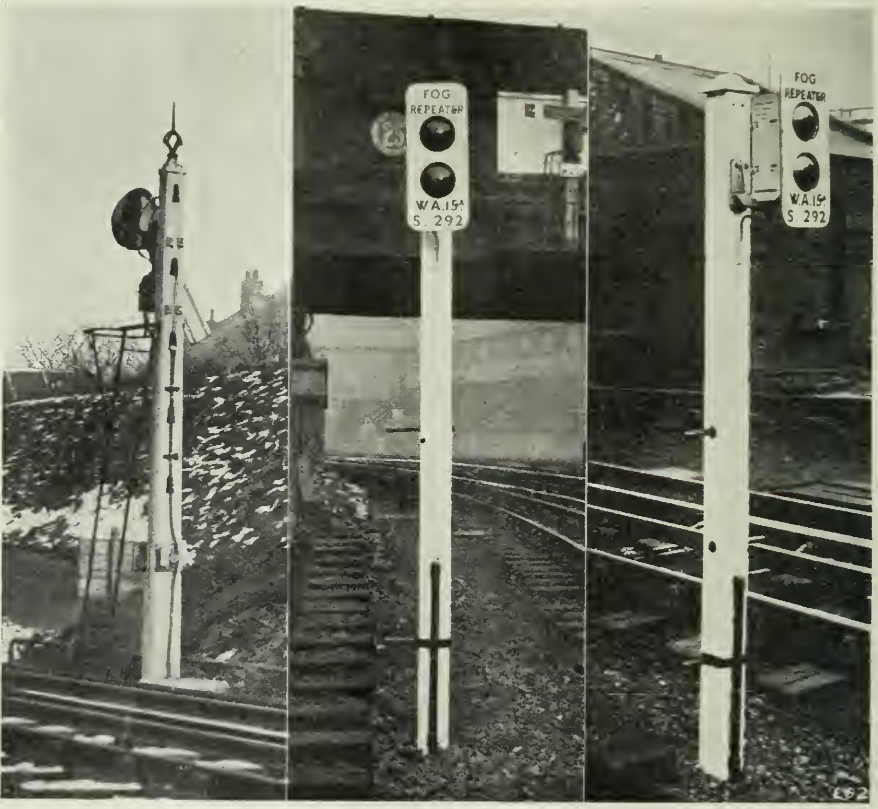
2. Battens are only required every 13 in., resulting in a great saving in wood and carpenter's work.

3. No nails are required.

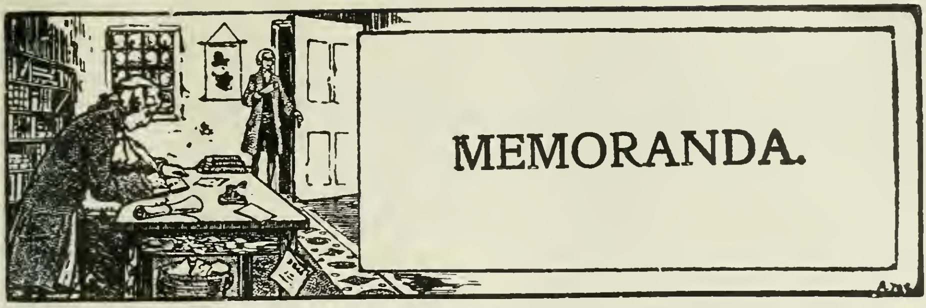
4. They are very easy to lay, and as only 140 have to be laid per square, less labour is required. The overall size of the tile is 15 in. by 9 in.

5. The surface is impermeable and harbours no germs ; the underlying battens being kept quite dry, will not suffer from dry rot.

For further particulars application should be made to the Express Guaranteed Corporation, 13, Golden Square, W.1.



Concrete Signal Posts.
(*See page* 411.)



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—Ed.

Concrete Signal Posts.—The illustrations on page 410 show some Concrete Signal Posts used on the District Railway.

Fig. 1 is the concrete signal post at Osterley and *Figs.* 2 and 3 are views of a Concrete Fog Repeater Signal Post near Earls Court.

It was decided some years ago to experiment with reinforced concrete signal posts on the District Railway and a number of 20 ft. posts were purchased and installed at various places on the railway. These signal posts were made on the well-known Marriott system and have a pleasing appearance.

The holes shown through the posts are put in to lighten same and a cavity extends inside the post for a distance of 8 ft. from the bottom for the same purpose.

The posts taper from 8 in. by 12 in. at the bottom to $5\frac{1}{2}$ in. by 7 in. at the top.

Care is taken to arrange for sufficient bolt holes before the posts are made, and allowances should be made for any likely alteration.

Owing to their weight, the posts are rather more difficult to erect than those made of timber, but the maintenance of same after erection is decidedly less, both for renewals and painting.

When fog repeater signals were installed, it was decided to use reinforced concrete posts for them, the post in this case being of a very simple design 5 in. square throughout their length of 12 ft. 6 in., the reinforcement consisting of 4 vertical $\frac{1}{4}$ in. bars with 13 ring ties $\frac{1}{16}$ in. diameter. The cap shown on the top of the post was fitted by the railway company after erection.

We are indebted for our particulars and illustrations to Mr. Arthur B. Cooper, Engineer, the Metropolitan District Railway.

Clinker Concrete.—The Municipal authorities at The Hague, who have carried out experiments with clinker from refuse destructors as a substitute for sand and gravel in concrete, have come to the conclusion that concrete made with clinker and flue dust is considerably lighter, more watertight, and only a little less strong than concrete made with gravel and sand. It has been successfully used for foundation work and similar purposes, and is recommended for house construction in districts where clinker may be readily obtained.

Silt in Concrete.—A series of tests carried out at California to determine the compressive strength of concrete made with cement and sand, containing fine silt in varying proportions up to 14 per cent. of the sand content, indicate that after 28 days the compressive strength of such concretes is reduced by 4·5 per cent. with the presence of 10 per cent. of silt, and that they are less permeable to water.

Cement and Iron Roads.—It is reported that an experiment at Lyons of road paving with star-shaped pieces of iron embedded in cement has been tried with great success.

CONCRETE AND HOUSING SCHEMES.

Durham.—Owing to the difficulty of obtaining supplies of bricks, the Durham Rural District Council is considering the question of using concrete for the houses in its housing scheme.

Grays.—The Ministry of Health has approved of the erection of ten concrete houses by the Grays (Essex) Urban District Council.

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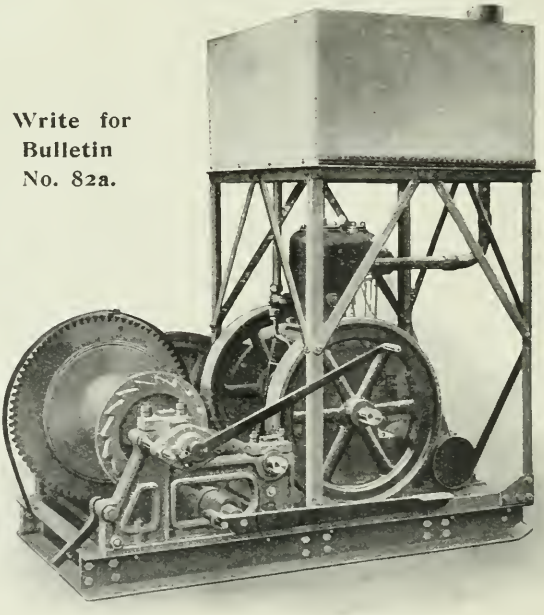

Illustration shows a single Barrel Winch adapted for Petrol drive, and can be fitted with Radiator or Tank.

THE BRITISH STEEL PILING CO.,
DOCK HOUSE, BILLITER STREET, LONDON, E.C.3.

Whitley.—The Whitley Urban District Council is considering the adoption of concrete for its housing scheme, owing to the difficulty of obtaining adequate supplies of bricks.

PROSPECTIVE NEW CONCRETE WORK.

Bournemouth.—*Coast Defence.*—The Borough Engineer has submitted to the Bournemouth Corporation a scheme for the protection of the coast, at a total cost of £182,500, and has recommended that the first portion of the work, estimated to cost £40,000, be put in hand as soon as possible.

Buckie.—*Harbour Works.*—The Buckie Town Council has received a loan from the Development Fund of £6,750 for improvements at the harbour.

Chichester.—*Waterworks.*—The Chichester Corporation has decided to carry out extensions at the waterworks, at a cost of £13,000.

Dundee.—*Sea-Wall.*—The Dundee Corporation has made application to the Scottish Office for a provisional order to empower it to widen Broughty Ferry Road and construct a sea wall, at an estimated cost of £206,000.

Hastings.—*Waterworks.*—The Hastings Corporation has decided to develop the Pebsham Waterworks, at an estimated cost of £16,000.

Hucknall.—*Reservoir.*—The Hucknall Urban District Council has been recommended by its Surveyor to proceed at once with the construction of a new reservoir.

Montrose.—*Harbour Works.*—The Montrose Harbour Commissioners have recommended the Montrose Town Council to repair the dock gates, etc., which collapsed during the war, at an estimated cost of £12,000.

Norwich.—The Norwich Education Committee proposes to erect a concrete retaining wall at Avenue Road School, at a cost of £350.

Nuneaton.—*Waterworks.*—The water clauses of the Nuneaton Corporation Bill, which empower the Corporation to build additional waterworks, at a cost of £170,000, have been passed by a House of Commons Committee.

Preston.—*Waterworks.*—A House of Lords Committee has passed the Preston Corporation Bill, which gives the Corporation authority to obtain an additional supply of water, at a cost of £750,000.

Rothesay.—*Pier.*—The Ministry of Health has held an inquiry with reference to the proposal of the Rothesay Town Council to extend the Albert Pier, at an estimated cost of £20,000.

Southampton.—*Harbour Works.*—The Southampton Town Council has decided to carry out improvements at the Harbour, at a cost of £20,000.

Surbiton.—*Open-Air Bath.*—The Public Health Committee of the Surbiton Urban District Council has instructed the Surveyor to prepare plans for the construction of an open-air swimming bath in the district.

Wakefield.—*Waterworks.*—The Wakefield Corporation has received Ministry of Health sanction to a loan of £15,000 for extensions at the waterworks.

TENDERS ACCEPTED.

Bickley (Kent).—The Metropolitan Water Board has accepted the tender of Messrs. Concrete Piling, Ltd., for the construction of a covered service reservoir at Bickley, for the sum of £18,529 2*s.*

Bournemouth.—The Bournemouth Town Council has accepted the tender of Messrs. Grounds & Newton, at £5,989 13*s.* 6*d.*, for the erection of a reinforced concrete bridge in St. Stephen's Road.

Bury St. Edmunds.—The Bury St. Edmunds Town Council has accepted the tender of Messrs. H. F. Sewell, of Bury St. Edmunds, for the construction of a concrete tank under the cooling tower at the Electricity Works, at £589.

Doncaster.—The Doncaster Corporation has accepted the tender of the British Reinforced Concrete Engineering Co., Ltd., for the erection of a reinforced concrete water tower near Cumthorpe Lane, at £6,487.

Harpenden.—The Hertfordshire County Council has accepted the tender of Messrs. K. Holst & Co. for the rebuilding of Pulsford Bridge, at £2,628.

Huddersfield.—The Huddersfield Town Council has decided to defer the work of erecting a new filter house and reinforced concrete tanks at Hill Top, Salendine Nook, for which tenders were recently invited.

Ipswich.—The following tenders were received by the Ipswich Corporation for the erection of 20 bungalows on the Racecourse site, for brick and concrete construction respectively:—Pollard & Skerritt, £742 2*s.* and £753 13*s.* 9*d.*; Cubitt & Gotts, £850 and £838; Long & Watling, £843 10*s.* (concrete); E. Catchpole, £882 and £892; V. A. Marriott, £970 and £965; P. J. Turner, £985 and £877; W. Harborough, £1,008 and £1,008. The tender of Messrs. Pollard & Skerritt has been accepted for brick houses.

Langham (Suffolk).—The East Suffolk County Council has accepted the tender of Messrs. J. Youngs & Son, Ltd., of Norwich, at £989, for the reconstruction of Langham bridge in reinforced concrete.

Merthyr.—The Merthyr Town Council has received the following tenders for the erection of eighty houses at Treharris, as follows: (*a*) 12 pairs parlour cottages (type 167); (*b*) 2 pairs non-parlour cottages (type 365); (*c*) 11 pairs parlour cottages (type 761); (*d*) 3 pairs non-parlour cottages (type 563); (*e*) 12 pairs parlour cottages (type 921). John Morgan: (*a*) £2,098 per pair; (*b*) £1,750; (*c*) £1,914; (*d*) £1,946; (*e*) £2,010. Thomas James, Ystrad Mynach: (*a*) £2,232 13*s.* 11*d.*; (*b*) £2,230 19*s.* 7*d.*; (*c*) £2,232 9*s.* 2*d.*; (*d*) £2,210 11*s.* 10*d.*; (*e*) £2,262 5*s.* 4*d.* Thomas Jones, Dowlais: (*a*) £2,180; (*b*) £1,842; (*c*) £1,874; (*d*) £1,890; (*e*) £2,084. Building and Public Works Construction, Ltd.: (*a*) £2,060; (*b*) £1,812; (*c*) £1,986; (*d*) £1,870; (*e*) £1,997. Adams' Housing Syndicate, Uxbridge: (*a*) £1,956; (*b*) £1,890; (*c*) £1,938; (*d*) £1,850; (*e*) £1,964. Corlways Concrete Walling,

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THE illustration below shows a typical "Victoria" Mixer fitted with engine and boiler plant. Where electric power is not available, or for special reasons petrol or oil fuel undesirable, the steam-driven mixer has much to recommend it, and forms a very compact and self-contained equipment. A highly efficient vertical boiler is mounted on the end of the truck. The boiler can conveniently be adapted for burning wood fuel. All the necessary fittings are provided. May we send you Catalogue M.D. 103?

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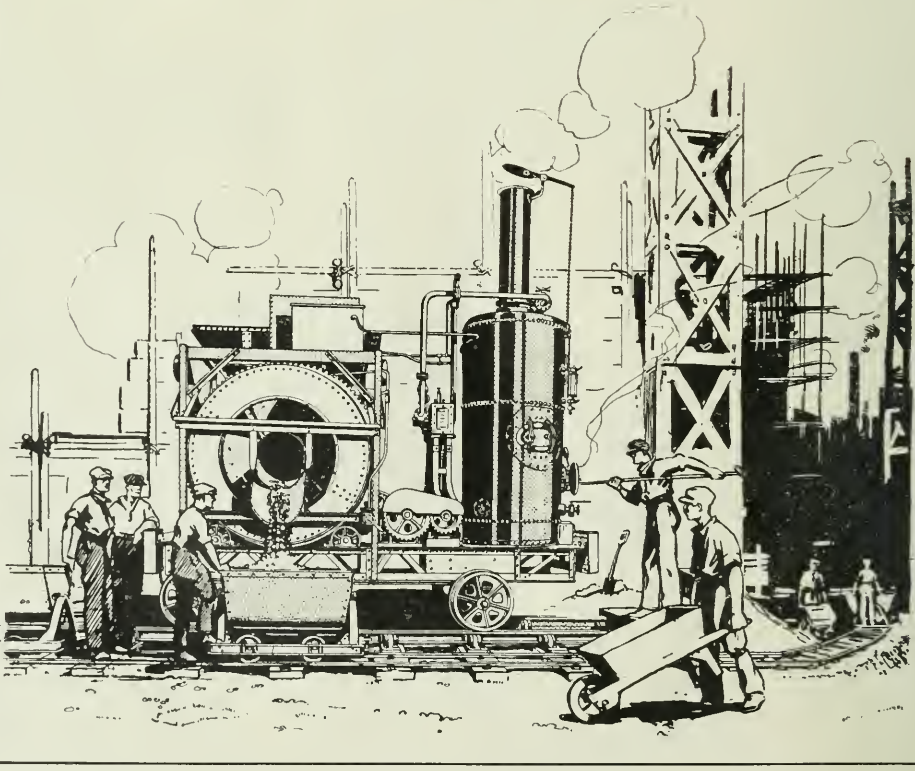

Ltd., Swansea : (*a*) £1,870 ; (*b*) £1,610 ; (*c*) £1,734 ; (*d*) £1,830 ; (*e*) £1,868. F. Hopkinson & Co., Ltd., Worksop : (*a*) £2,119 4*s.* ; (*b*) £1,927 15*s.* ; (*c*) £2,099 15*s.* ; (*d*) £1,917 17*s.* ; (*e*) £2,106 14*s.* 6*d.* All the above prices tenders are per pair of houses. The tenders have been referred to the Housing Commissioner.

Redditch.—The Redditch Urban District Council has received the following tenders for the erection of 32 non-parlour houses (the tenders are per house for hipped and plain roofs respectively) : Unit Construction Co., Ltd. (concrete blocks), £685 and £688 ; J. and A. Brazier, Bromsgrove, £704 and £701 ; Housing, Ltd., Birmingham, £712 and £713 ; Redditch Master Builders' Association, Redditch, £779 and £770 ; H. M. Grant & Co., Birmingham, £785 and £785 ; Bridgewater Bros., Cradley, £798 and £798 ; Thos. Rowbottam, Birmingham, £803 and £794 ; Mills Bros., Redditch, £810 and £810 ; Tilt Bros., Bromsgrove, £904 and £893. The tender of Messrs. J. and A. Brazier has been recommended for acceptance.

Romsey.—The Romsey (Hants) Rural District Council has accepted the tender of the British Construction Co., of London, for the reconstruction in reinforced concrete of the bridge and penstock at Kimbridge, at £1,400.

Sheffield.—The Sheffield Town Council has accepted the tender of the Sheffield Building Trades' Employers' Association for the erection of the following houses on the "Duo-Slab" concrete system on the Mann Estate :—78 parlour houses, at £830 per house ; and 319 non-parlour houses, at £730 per house.

Stamford.—The Stamford Town Council has received the following tenders for the erection of 66 houses : J. Morgan, £51,154 7*s.* ; W. C. Morgan (Panels, Ltd., system of construction), £56,440 ; W. C. Morgan, £60,370 ; Sims, Sons & Cooke, £56,900 ; F. R. Hipperson, £61,046 ; Interloc Building Construction Co., £61,380 ; E. J. W. Wilson, £62,201 ; Hinson & Co., £63,292 ; E. Ireson, £64,406 ; Thornhill Bros., £68,842 ; Clarke & Belton, £69,229 10*s.* ; Pattinson & Sons, Ltd., £69,460 ; Flotter & Son, £71,147 7*s.* 8*d.* The tender of Mr. J. Morgan has been provisionally accepted.

Strood (Kent).—The Strood Rural District Council has received the following tenders for the erection of ten houses at Wainscott :—Messrs. Richardson, Canterbury Street, Gillingham, £12,300 in brick, or £200 less if built in concrete ; Messrs. J. Logan, High Holborn, W.C., £10,412 in brick, or £300 less if in concrete ; Adams Housing Syndicate (special system of construction), £9,610. The tenders have been sent to the Housing Commissioners.

Tilbury.—The Tilbury Urban District Council has accepted the tender of the Patent Impervious Stone Co. for the erection of 250 concrete houses, on the "Winget" system, at the North Ward. The contract price is £221,500.

Weston-super-Mare.—The Somerset Urban District Council has accepted the tender of Messrs. E. Ireland, of Bath, at £3,412, for the reconstruction in reinforced concrete of three bridges on the Bristol-Weston-super-Mare road between Congresbury and Worle.

TENDERS INVITED.

Greenwich.—June 13. Erection of 128 pairs of houses on the Charlton Estate, for the Greenwich Borough Council. Plans, etc., from the Town Clerk's Department, Town Hall, Greenwich, S.E. Deposit, £2 2*s.*

Coventry.—June 17. Erection of a new sorting office, for H.M. Office of Works. Plans, etc., from Contracts Branch, H.M. Office of Works, King Charles Street, S.W.1. Deposit, £1 1*s.*

Pulborough.—June 30. The Pulborough Rural District Council invites tenders for the erection of 30 cottages. Plans, etc., from Mr. P. Ayling, Clerk to the Council, Storrington, Pulborough.

South Africa.—July 5. The date for the receipt of tenders for grain elevators, for the South African Railways and Harbours Board, has been extended to July 5. Specifications, etc., from Mr. R.A. Blankenberg, Secretary, Office of the High Commissioner for the Union of South Africa, Trafalgar Square, London, S.W.

Bombay.—July 26. The date for the receipt of tenders for the construction of 105 miles of steel and reinforced concrete pipe-lines in connection with the Bombay water supply, for the Bombay Corporation, has been extended from May 31 to July 26. Specifications, etc., from Messrs. Taylor & Sons, Consulting Engineers, 36, Victoria Street, Westminster, S.W. Deposit, £100.

NEW COMPANIES REGISTERED.

Henry Wilde, Ltd. (173,885). Registered March 24. 66, Victoria Street, S.W.1. Builders and decorators. Nominal capital, £13,000, in 12,000 £1 preference shares and 20,000 £1 ordinary shares. Directors to be appointed by subscribers. Qualification of directors, £25 ; remuneration, £25 each.

Porous Drainage Construction Co., Ltd. (174,076). 7, Tithebarn Street, Liverpool. Registered April 5. To acquire inventions relating to the manufacture of porous concrete pipes. Nominal capital, £2,000, in 2,000 £1 shares. Directors : J. A. Glendinning, 84, Conduit Street, Leicester ; A. Gordon, 7, Tithebarn Street, Liverpool ; and T. J. Benjamin, 60, Castle Street, Liverpool. Qualification of directors, £20 ; remuneration to be voted by Company.

The British Block & Slab Co., Ltd. (174,132). Registered April 9. Manufacturers of artificial stone, and building slabs and blocks. Nominal capital, £1,000, in 1,000 £1 ordinary shares. Directors to be appointed by subscribers ; qualification, 50 shares ; remuneration to be voted by Company. Subscribers : A. C. Woodward, 5, Bandflower Road, S.W. ; H. Kloss, 98, St. John's Hill, S.W. ; R. Klos, 102, St. John's Hill, S.W. ; and J. de Sacc, 34, East Hill, S.W.

Wilson's Asbestos Cement, Ltd. (174,264). Registered April 16. 79, Queen Street, London, E.C. Specialists in all kinds of asbestos-cement buildings and building materials. Nominal capital, £5,000, in 4,000 £1 preference shares and 4,000 5*s.* ordinary shares. Directors : W. J. E. Wilson, Dalby House, Cliftonville, Kent ; G. S. Oxenford, Ferniehurst, Shelley Road, Worthing ; and A. D. Parkinson, 81, Etchingham Park Road, Church End, Finchley. Qualification of directors, one share ; remuneration, £52 each.

Walker Concrete Co., Ltd. (174,428). Registered April 27. Manufacturers of concrete and artificial stone. Nominal capital, £3.000, in 3,000 £1 shares. Directors: A. Dingwall, 33, Fisher Street, Walker-on-Tyne, and T. Wanless, Cragg House, Walker-on-Tyne. Qualification of directors, £250; remuneration, £200 each.

Lancashire Concrete Block and Construction Co., Ltd. (174,566). Registered May 5. 62, Sankey Street, Warrington. Concrete block manufacturers. Nominal capital, £2,000, in 2,000 £1 shares. Directors: H. Rogers, Feathers Hotel, Bridge Street, Warrington; W. J. Mather, 13, Millfield Road, Widnes; and E. Downs, 67, Ellesmere Road, Lower Walton, Lancashire. Qualification of directors, £1; remuneration to be voted by Company.

British Roofing Co., Ltd. (174,612). Registered May 9. Manufacturers of asbestos cement sheets and slates and roofing felts. Nominal capital, £5,000, in 5,000 £1 shares. Directors: A. C. J. Green, Foye, Romford; A. C. Fletcher, 1, Palmeira Avenue, Hove; and F. Hotton, 62, Earl's Hall Road, Well Hall. Qualification of directors, 1 share; remuneration, £300 each.

The Clarwood Company, Ltd. (174,613). Registered May 9. 6, Bream's Buildings, Chancery Lane, W.C. Concrete manufacturers and builders' merchants. Nominal capital, £1,000, in 1,000 1s. shares, 500 £1 preference shares, and 450 £1 ordinary shares. Directors: C. J. J. B. Clark, 1, Ravensbourne Gardens, Ealing; W. E. Woodbridge, 34, Westborough Road, Westcliff-on-Sea; and H. A. Kellaway, 8, Selsdon Road, West Norwood, S.E. Qualification of directors, £100; remuneration, £325 to be divided.

RECENT PATENT APPLICATIONS.

112,450.—W. C. Davis: Reinforcement for concrete parapets, balconies, railings, fences and similar structures.
130,982.—M. Ordfrud: Moulds for concrete buildings.
134,827.—A. Duffieux: Building blocks.
137,053.—A. M. Poulson: Reinforcement for concrete.
137,850.—W. A. Curless & Co.: Cement pipe-making machine.
143,243.—K. G. Wennerstrom: Manufacture of cement.
145,426.—W. McLeod: Monolithic concrete construction and machinery.
146,172.—A Sinding-Larsen: Porous cement and mortar manufacture.
157,510.—E. L. Warren and W. G. Parker: Concrete block-making machines.
157,589.—E. Keel: Hollow-block making machine.
157,638.—W. Rooke: Building blocks.
158,012.—P. C. Cannon: Apparatus for manufacturing concrete blocks, pipes, posts, girders, etc.
158,025.—G. Cave: Concrete junction piers for cavity walls.
158,075.—H. Telling: Filleted concrete building blocks
158,189.—E. J. Elgood: Building slabs.
158,356.—J. G. Whitelege: Buildings and blockcast *in situ*.
158,390.—H. D. Baylor: Manufacture of slow-setting cement.
158,397.—W. J. Mellersh-Jackson: Concrete floors and roofs.
158,493.—P. C. Cannon: Manufacture of concrete, blocks, pipes, etc.
158,588.—Sir J. P. Fitzpatrick and B. Bradley: Concrete pipe construction.
158,596.—G. Carter: Building blocks.
158,703.—W. J. Mellersh-Jackson: Concrete floors and roofs.
159,002.—C. R. Burton: Wall construction.
159,007.—J. E. Wallis: Building construction.
159,066.—G. Lillington: Floors, walls, and ceilings.
159,239.—C. M. C. Hughes, A. E. Brown, and T. Hill-Jones, Ltd.: Manufacture of building blocks, slabs, and tiles.
159,256.—A. M. Bowley: Concrete floors.
159,268.—F. W. Duckham: Piers for quays or retaining walls.
159,711.—F. Emmrich: Cores for hollow concrete construction.
159,731.—R. Last: Concrete pipe-making machine.
159,780.—A. Hauenschild: Method of and apparatus for calcining cement.
159,954.—W. Watson: Soffit for carrying concrete floors.
159,979.—A. P. Laurie, E. R. Sutcliffe, and Sutcliffe, Speakman & Co., Ltd.: Materials for the manufacture of building blocks and slabs.
159,990.—C. P. Lovell: Building blocks and bricks.
160,226.—W. F. Ballinger and E. G. Perrot: Reinforced concrete and timber walls.
160,306.—F. T. Gray and R. G. Whitaker, Ltd.: Concrete blockmaking machines.
160,329.—B. Green: Shuttering for reinforced concrete construction.
160,551.—W. R. Hume: Manufacture of articles of concrete.
160,556.—E. R. Sutcliffe: Apparatus for the hydration of lime.
160,647.—A. P. Laurie: Hollow wall construction.
160,650.—J. Sykes: Concrete building blocks.
160,867.—L. P. Evans: Shuttering for concrete work.
160,936.—W. Brownhill and Dickinson & Co., Ltd.: Floor construction.
160,974.—F. J. Collingwood: Manufacture of building blocks and bricks.
160,999.—J. Shortt: Building blocks.
161,002.—J. T. Simpson: Reinforced concrete construction.
161,016.—H. Dean: Building blocks.
161,071.—F. W. Bradshaw: Reinforced concrete columns and posts.
161,258.—C. M. J. Roch and L. C. Mouchel and Partners, Ltd.: Pre-cast reinforced concrete columns, beams, slabs, and beams for house construction.
161,596.—T. F. Hoare: Framed sections for building construction.
161,614.—J. F. Matthews: Reinforced concrete construction.
161,631.—E. Airey: Concrete walls, pillars and piers.
161,677.—E. and A. P. Hurden and S. E. Beeson: Walls and partitions.
161,712.—C. Giles: Damp and condensation proof walls.
161,790.—W. Shufflebottom and T. Kenworthy: Concrete building blocks and wall construction.
161,824.—N. S. Chedburn and W. R. Chalmers: Construction of *in situ* concrete walls.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 7. London, July, 1921.

EDITORIAL NOTES.

THE CONCRETE INSTITUTE AND RESEARCH.

Slowly, but we hope surely, the value of research is becoming generally recognised. As processes develop the need of the scientist's aid becomes increasingly apparent, and as costs rise the necessity for economy makes itself more and more felt. It is only by an intimate knowledge of the fundamental attributes of our materials that we can really hope to use them to the best advantage, and this knowledge can only be obtained by patient investigation. In times past the man of science displayed little interest in the technical application of the principles he unravelled and expounded, but time has brought changes and at the present day it is quite astonishing to find the amount of sympathy displayed by those whose work lies mainly in an academic sphere with the material issues which so greatly concern engineers and others dealing with constructional matters. This attitude is well exemplified in the relation which the Concrete Institute has established with a large number of university colleges and other centres of research and learning. In 1914 proposals were put forward for the investigation of local aggregates suitable for concrete in the United Kingdom, and now after somewhat protracted negotiations with the Department of Industrial Research, which has supplied part of the necessary funds, we have before us an interim report * of this department on the work so far done. This report shows that a very careful survey of the problem has been made by the Science Committee of the Concrete Institute and most explicit instructions issued to investigators. Many tons of cement presented for the work have been tested and distributed in sealed drums to preclude variations in the results from this constituent of the concretes made. Aggregates of gravel, quartzite, dolorite and andesite have already come under investigation and the results to date are given in a number of appendices. Of course in all concrete tests there is a certain element of personality due to the investigator and it would possibly have been better had all the experiments been carried out at one centre, but we imagine that this was found to be impracticable owing to the magnitude of the work. Against any objection to distribution we have as a set-off the very wide interest in the work of the Institute and in concrete products which this decentralisation must undoubtedly create, and we do not suppose that when this series of experiments is concluded the valuable connection thus established will be allowed to drop into oblivion. Cement makers and concrete users should welcome the results and the inferences which it is yet too early to draw from them,and we hope that finally a digest with simple tabular data will be made generally available. If this is done we imagine that

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* Published by the Concrete Institute, 296 Vauxhall Bridge Road, S.W.1. Price 1s. 7d., post free.

such matter will be very widely appreciated and become a standard for reference, which will do much to help the best use of materials and incidentally to enhance the fame of the Institution which has initiated so valuable an undertaking.

THE COST OF CONCRETE COTTAGES.

One of the most striking features of the tenders now being received by local authorities for housing schemes is the small difference between those submitted for concrete construction and those for brick. All the prices show a reduction compared with those ruling only a few months ago, but while brick cottages have come down in some cases by as much as £200 each, the prices for concrete cottages have not been reduced in anything like the same proportion, and at the present time there is very little difference between the two methods as regards cost; in some cases, indeed, the tenders for concrete have been slightly in excess of those for brick for the same type of cottage. The position is one that requires careful attention, for, although the economy rendered essential by the existing financial stringency must have a considerable influence in the adoption of the cheapest form of building, if the extra cost of brickwork is almost negligible, as it appears to be at present, it is very probable that the older and better-known method of construction may be adopted to the exclusion of concrete. It must be remembered that concrete as a medium for cottage construction was used during the war and after more or less as a substitute owing to the difficulty of obtaining the ordinary materials, and that its present use will be maintained or increased mainly on account of its cheapness.

It is urgently necessary that every effort should be made to cheapen the cost of making concrete and concrete blocks, and that every facility should be given to the operatives to enable them to give the maximum output. Out-of-date methods should be ruthlessly scrapped, and labour-saving devices employed at every opportunity. There is undoubtedly a considerable scope for cheapening concrete construction by a greater use of machinery in building monolithic walls or making concrete blocks by taking the fullest advantage of the excellent choice of machinery now available.

In practically every other industry machinery is introduced to perform operations in which even the smallest saving is effected, but the conservatism of the average builder is hard to overcome. It is certain, however, that if he can quote for concrete cottages at a lower price than his competitors can quote for brick he will get the work, and with a full and intelligent use of labour-saving machinery we are convinced that this is possible. Of course, the small builder will object that the first cost and consequent overhead charges would be heavy. But would they? For instance, thoroughly efficient mixers can now be obtained for £100 or a little more, fitted with petrol or paraffin engine that costs only a few pence per hour to run, capable of turning out up to 70 or 80 cubic yards a day, and, what is important to a builder whose jobs are scattered, can almost be transported from one site to another on a hand truck. Compared with the saving in labour, and the better concrete obtained, the overhead charges on such a machine, which will last several years without requiring renewal, are hardly a consideration, even if the machine be lying idle for as long as six months in the year. The same applies to block-makers and other plant. A well-designed hand-operated concrete block-making machine costing less than £100, of which there are many on the market, will turn out sufficient concrete blocks or bricks of standard size in ten working days to build a working-class house, and one of these machines is therefore sufficient to provide all the walling necessary for the smaller housing schemes. Furthermore, most of these machines can be readily adapted for manufacturing sills, lintels, quoins, etc. An official report issued by the Building Research Board estimates that by the use of such plant concrete bricks of standard size can be made at £2 10*s*. per thousand. These bricks are equivalent in every respect, and superior in strength, to the best bricks, which now cost, roughly, £5 per thousand, according to where they are delivered. So that in places where suitable aggregate is available concrete bricks cost about half as much as ordinary bricks, and in addition the risk of the work being held up owing to the non-delivery of bricks, which is a very frequent occurrence just now, is eliminated. These machines are now well past the experimental stage, and it is up to the small builder to take the fullest advantage of them. The large schemes where hundreds of houses are being built by contracting firms are not the only jobs to be had, and if concrete houses are built cheaper than brick, as they certainly can be if builders lay themselves out to undertake concrete building on up-to-date lines, many of the smaller schemes now being held up on the ground of cost would be proceeded with.

With regard to labour, the increase of the bricklayer's output to such an extent as has been noticeable recently has been a big factor in the decreased cost of brickwork, and has only been possible because it was admittedly often restricted before. But if the concrete worker cannot be speeded up in the same ratio, he can be helped considerably by improved organisation to ensure a constant supply of materials, suitable scaffolding, efficient and simple shuttering if the construction be monolithic, and by being supplied with the best tools to do his work, *i.e.*, machinery. When concrete has been longer in vogue as a medium for cottage building there will be a large body of men skilled in the work available, and this will make itself felt in speedier and cheaper construction by the elimination of the necessity for training men on each job. Concrete building, for which a larger proportion of unskilled men is used, will also be helped by the wider demarcation between the wages of skilled and unskilled men likely to be agreed to in the near future. Already a penny an hour more has been taken off the wages of the unskilled men than the skilled, and negotiations are in progress for a still larger comparative reduction.

But it is not only in reductions in wages that any appreciable decrease in concrete construction costs may be looked to ; it is in the efforts of the builders to grapple with the work on up-to-date lines that the hope for the future lies.

The question of building houses at a price which will be attractive to the ordinary investor is one that has to be borne in mind, and construction in concrete would appear to offer the best field for development with this end in view, for the day of the subsidised building must surely soon come to an end.

THE ACTION OF SEA WATER AND OIL ON CONCRETE.

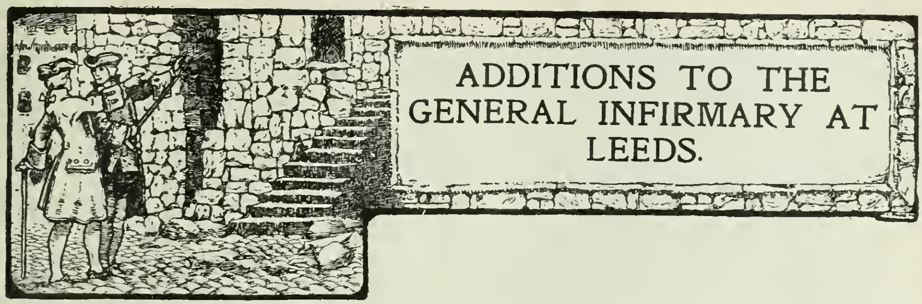
An experiment carried out by the Aberthaw Construction Company, of Boston, to test the action of sea water on concrete has yielded some interesting results. In January, 1909, twenty-four piers, each 16 ft. long, were manufactured with various cements, broken traprock, and clean sharp sand, mixed in various proportions, and of different consistencies. The specimens were cast with rods through the centre by which they could be suspended, and after being stored for five weeks they were suspended under a wharf in the United States Navy Yard, Boston, in such a position that the bottom ends would always be immersed and the tops always above high-water level, the intermediate parts being alternately covered and uncovered with the rise and fall of the tide.

From time to time the specimens were taken out of the water and examined and photographed, and the results of the experiment up to the middle of last year have now been published. The most noteworthy result is that in the specimens made of exactly the same materials, in the same proportions, and under the same conditions, those which were mixed very wet have stood the test far better than those which were mixed dry. In fact, the specimens which were mixed to a dry consistency have cracked, split, and finally in many cases practically fallen to pieces, the deterioration being more pronounced each time they were inspected, whereas the specimens mixed to a wet consistency ("soft enough to run out of an overturned barrow," and when cast "quaked with a very light tamping") are reported to be in very good condition, with sharp corners still unbroken in some cases.

At the last inspection, in 1920, an unexpected state of affairs was discovered, for it was found that all the specimens were coated with a thick, tenacious, black substance, resembling tar, wherever they had been in the water. This was found to be due to the fact that many of the battleships in the harbour had been using fuel oil, and it was this material floating on the water that had coated the specimens. Those undertaking the experiment were, however, surprised to find that far from having any injurious effect on the concrete, this coating had acted as a preservative, and not only kept the specimens free from barnacles and other forms of marine life which had previously clung to them in profusion, but also caused the corrosion to cease. "This coating," they state, "to all appearances offers a complete protection to concrete surfaces which usually suffer from intermittent contact with salt water and the upper elements . . . and since conditions in most harbours are likely to be similar to those in Boston Harbour, there is apparently a great deal of opportunity for floating oil to work good as well as harm."

NOTES.

Cornwall.—At a recent meeting of the Mid & West Cornwall Employment Committee, Sir Arthur Carkeek (Chairman) outlined a proposal for the relief of the local unemployment by inaugurating a scheme for the manufacture of concrete units for use on housing schemes and small holdings. The unemployed are chiefly from the local clay works, which are now almost at a standstill, and the mine-owners in the district have offered to place their waste dumps at the disposal of the Committee for the purpose. The Committee has submitted a recommendation to the Agriculture and Small Holdings Committees in the area pointing out the advantages that would accrue, not only from the point of view of the relief of unemployment but also from the point of view of obtaining cheap articles, if the offer of the mine-owners were taken advantage of and concrete blocks, bricks, fences, posts, pipes, etc. manufactured from the material. Providing no profit is made on the undertaking by the local authorities, 60 per cent. of the wages paid will be refunded by the Unemployment Grants Committee. It is anticipated that the scheme will provide work for about one hundred men, besides forming a local centre from which an adequate supply of concrete building material will be obtainable.

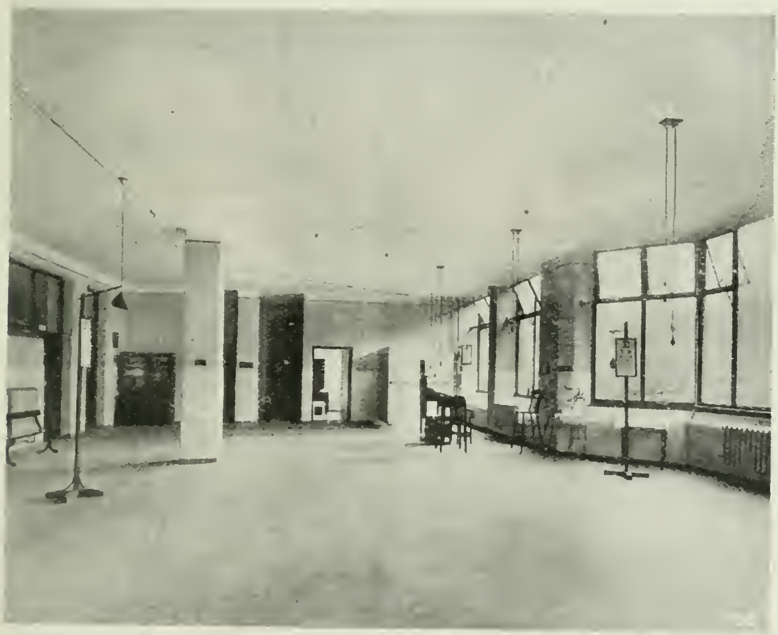


ADDITIONS TO THE GENERAL INFIRMARY AT LEEDS.

We are now able to reproduce illustrations and particulars of the improvements and extensions which were carried out during the war at the General Infirmary, Leeds.

As a matter of fact, these improvements had been decided upon several years previous to the war, in commemoration of the reign of His late Majesty King Edward VII.

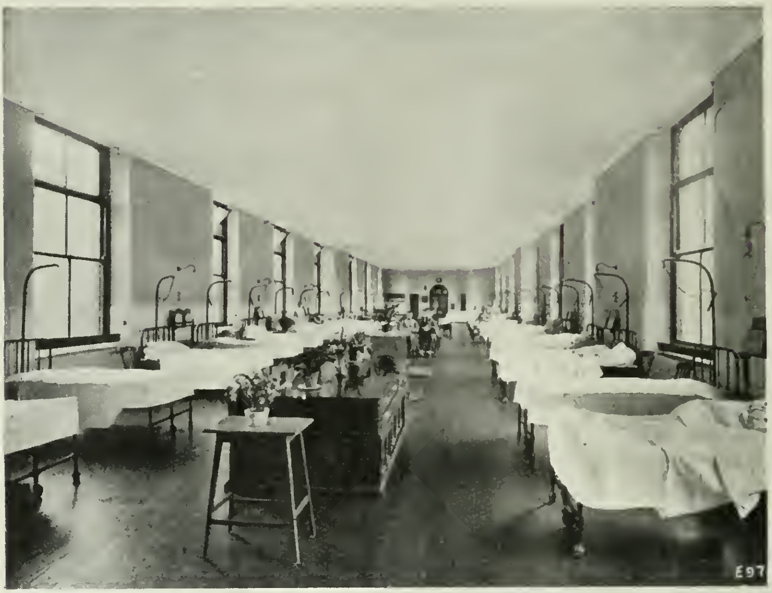
The work, however, was considerably delayed on account of the difficulties in providing a suitable site for the extensions, and also on account of the cost of the new buildings, which amounted to upwards of £150,000, and which had to be raised entirely by voluntary contributions.



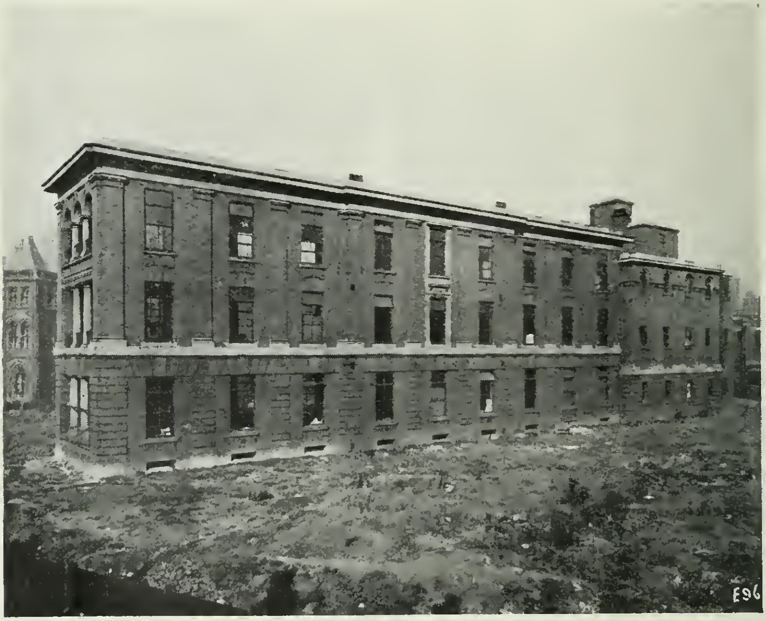
Eye and Ear Department.
Additions to the Leeds Infirmary.

The extensions, which we briefly describe here, were started in 1914, and, of course, they were rendered all the more necessary by the exigencies of the war.

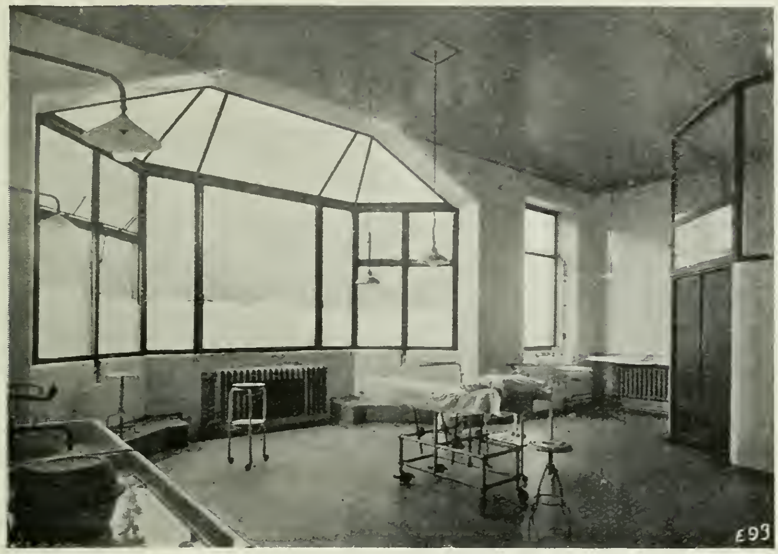
In spite of the considerable difficulties encountered in obtaining the necessary



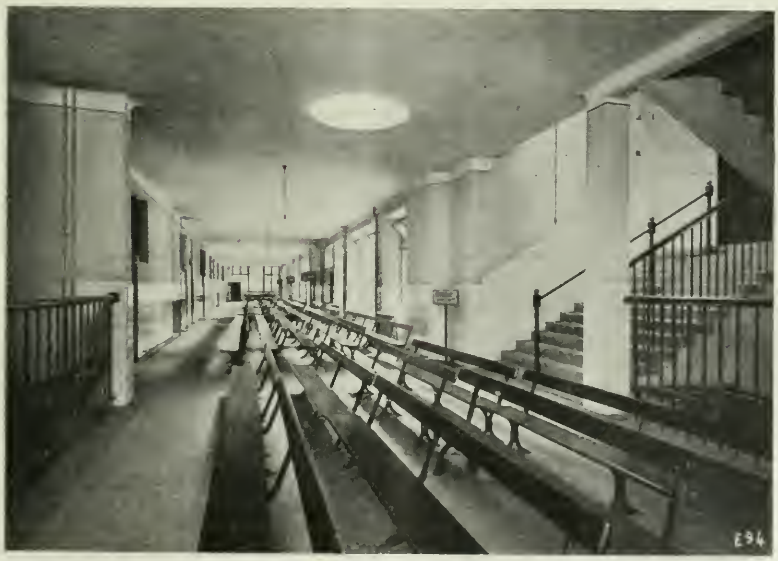
New Ward Pavilion. Interior View.
ADDITIONS TO THE LEEDS INFIRMARY.



New Ward Pavilion. Exterior View.
ADDITIONS TO THE LEEDS INFIRMARY.



One of the Operating Theatres.
ADDITIONS TO THE LEEDS INFIRMARY.



Out-patients' Waiting Hall.
ADDITIONS TO THE LEEDS INFIRMARY.

materials and labour, the work was pushed on with the utmost speed, so that the work was completed in time for the buildings to be of the greatest use.

Messrs. Kitson, Parish & Lidgard, of Leeds, were appointed as Architects for the new work, which was entrusted to Messrs. Henry Atkinson & Sons, Ltd., Contractors, of Leeds.

Briefly, the extensions included a building in the shape of an L, the main portion of which is approximately 250 ft. long by 55 ft. wide, with a wing of 45 ft. long by 45 ft. wide.

This building contains operating theatres and the necessary accommodation for nurses and doctors on the principal floor, and on the lower floor a New Surgical Out-Patient Department.

The other building, which has approximately a length of 100 ft. and a width of 45 ft., is for the purpose of additional wards and forms an entirely new wing. The two buildings are connected by a footbridge.

Both these buildings have floors and flat roofs which have been constructed on the Coignet system of reinforced concrete. The stairs connecting the various floors are also in reinforced concrete. The walls of both buildings are constructed in brickwork.

Apart from the above buildings, a new Boiler House and Laundry have been erected.

The reinforced concrete floors were calculated to support a load of 1 cwt. per foot super, with a test load of 50 per cent. in addition to the superload. The roofs were designed for a load of $\frac{3}{4}$ cwt. per square foot.

The undersides of practically all the floors are provided with a false ceiling of expanded metal suspended to the reinforced concrete beams, the latter requirements being, of course, for the purpose of better ventilation and sanitation.

Very great care was taken to see that all angles between ceilings and walls should be coved.

The floors of the large wards and private wards were covered with teak floor boards. The remaining floors and corridors, however, were finished with a smooth coating of cement covered over with Terrazzo Paving.

The whole of the reinforcement for the pillars, beams and slabs was composed of round bars of mild steel, varying in diameter between $\frac{3}{16}$th in. and $1\frac{1}{4}$ in., and all the plans for the reinforced concrete work were prepared by Messrs. Edmond Coignet, Ltd., Reinforced Concrete Consulting Engineers, of Westminster.

MEMORANDA.

Research.—At the Motor Research House to be opened in Chiswick in September next, it is proposed to make some experiments to ascertain the rolling resistance of motor vehicles. The testing is to be done on a concrete track and a special recording instrument installed in the house will be used for taking observations.

Concrete Silos.—The authorities of Armstrong College, Newcastle-on-Tyne, are considering a proposal to erect a concrete silo at the College, in order to demonstrate to farmers the advantages of concrete over other materials for the construction of such buildings for the storage of grain, fodder, etc.

Lagos Harbour.—The contract in connection with the wharfage scheme at Apapa, Lagos Harbour, has been let to the civil engineering and contracting department of Messrs. Sir W. G. Armstrong, Whitworth & Co. The work will be carried out by the Nigerian Government and includes a deep water berthage for ocean-going steamers, a concrete blockwork quay wall of some 1,800 ft. in length, five transit sheds, reclamation of foreshore and dredging for steamer berths in front of the quay wall.

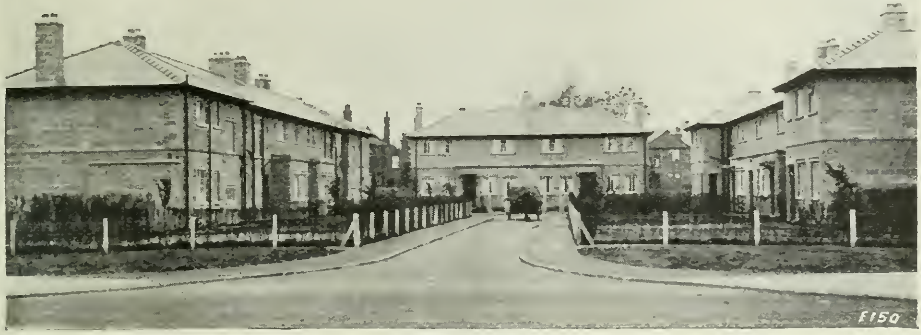


Fig. 1. Quadrangle, No. 1.
Southport Housing Scheme.

CONCRETE HOUSE BUILDING.

HOUSING SCHEME AT SOUTHPORT.

It is a little more than a year since work was begun on the foundations of the Southport Housing Scheme. Last month—just a year after the commencement of the work—the walling of 200 houses was completed, 180 were roofed in, 42 are now occupied and 5 houses are being handed over to the Corporation each week for occupation. This is rapid work and denotes good organisation, and it is doubtful if such expeditious results would have been obtained had the houses been constructed in brickwork instead of concrete. The contract is divided into three sites situated about two miles apart, comprising 124, 56 and 26 houses respectively. The system adopted is that of the Unit Construction Company, who are also acting as contractors.

The lay-out of the three sites is the work of Mr. A. E. Jackson, A.M.I.C.E., the Borough Engineer of Southport, who is acting as Housing Director to the Corporation, Mr. H. E. Ford, A.M.I.C.E., being engineering assistant. *Fig.* 2 shows the lay-out of the Ash Lane site; the houses are arranged, it will be observed, on axial lines, and each house is provided with a spacious garden, and the main roads are pleasantly lined with trees. The Crossens site is an awkward shaped piece of land, in which existing roads had to be linked up.

The houses are in pairs and fours and include parlour and non-parlour types with three and four bedrooms. There are also blocks of flats. *Fig.* 3 is of a block of four; one of the houses has a large first floor, on account of its inclusion of the passage below, and thus has four bedrooms. The remainder have three; all the rooms are spacious and the houses are not cramped. *Fig.* 4 is a block of two, and *Fig.* 5 a pair of flats. The accommodation here is a large living-room, two bedrooms, scullery and bath-room. A completely separate entrance is arranged for each flat. It is in fact a block of two dwellings with a party floor instead of a party wall. The planning is compact and provides on both floors for an open lobby to the w.c., and a dust bin placed in the open. The interiors of the houses are well finished, picture rails being provided in each room, and not—as is so often the case to-day—in the sitting-rooms only. Cupboards and drawers are

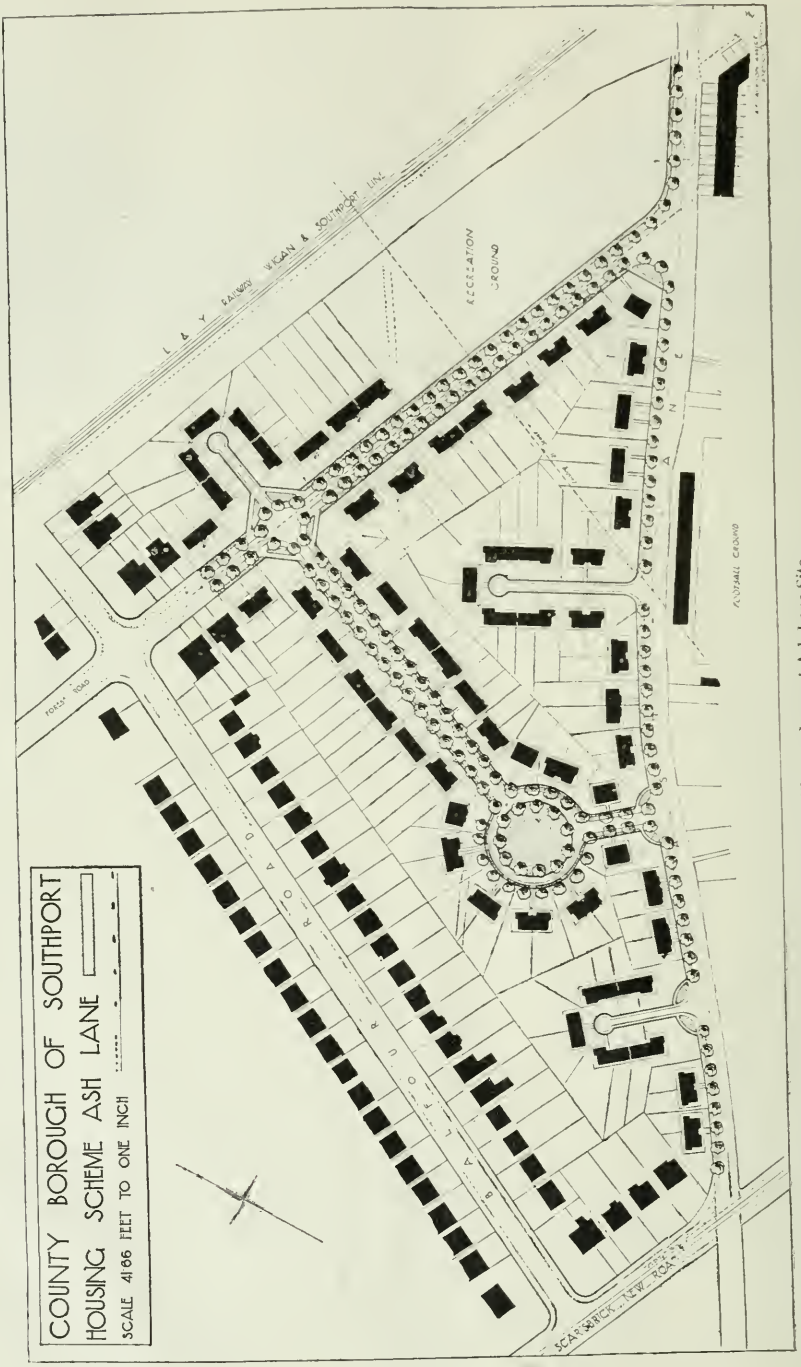


Fig. 2. Lay-out Ash Lane Site.
Southport Housing Scheme.

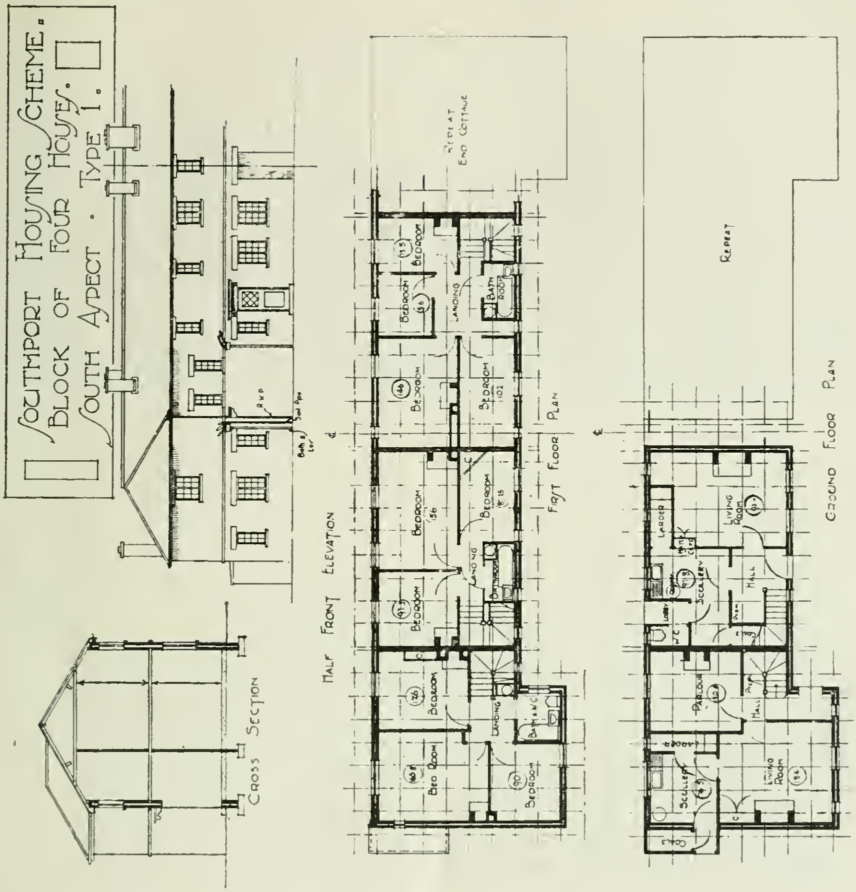


Fig. 3. A Block of Four Houses.

Southport Housing Scheme.

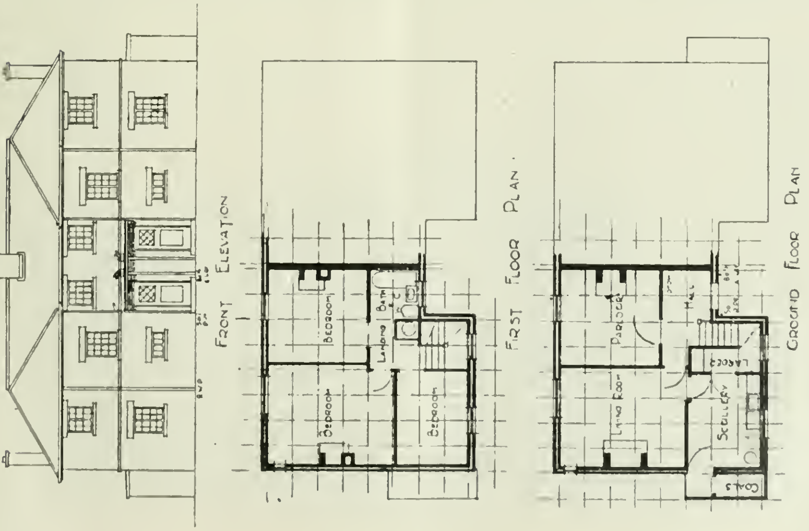


Fig. 4. A Pair of Houses. North Aspect. Type 2A.

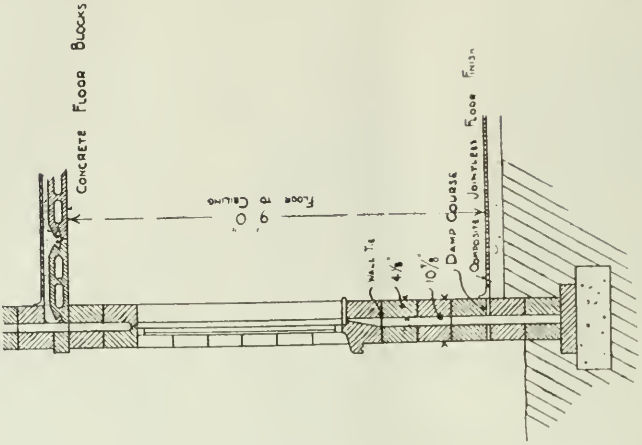


Fig. 6. Section of Wall.

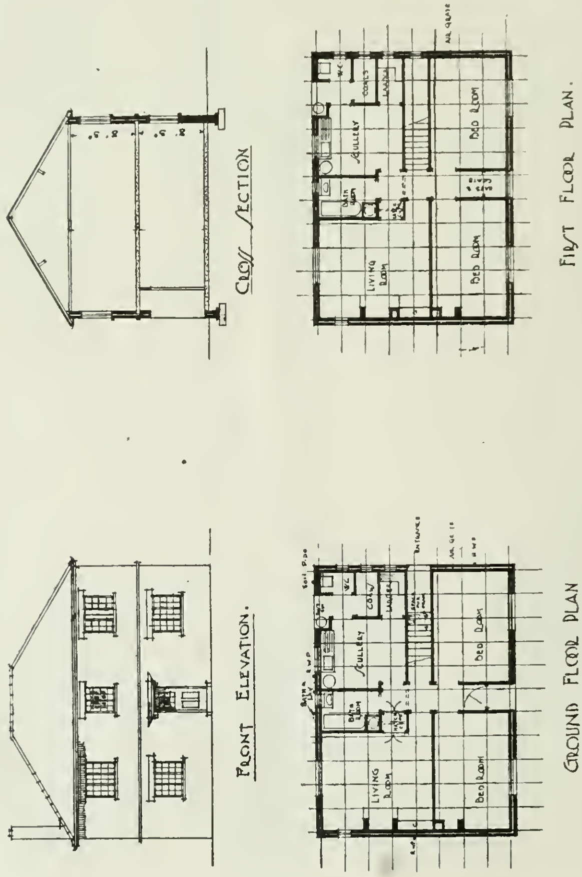


Fig. 5. Flatted Type of House.

Southport Housing Scheme.

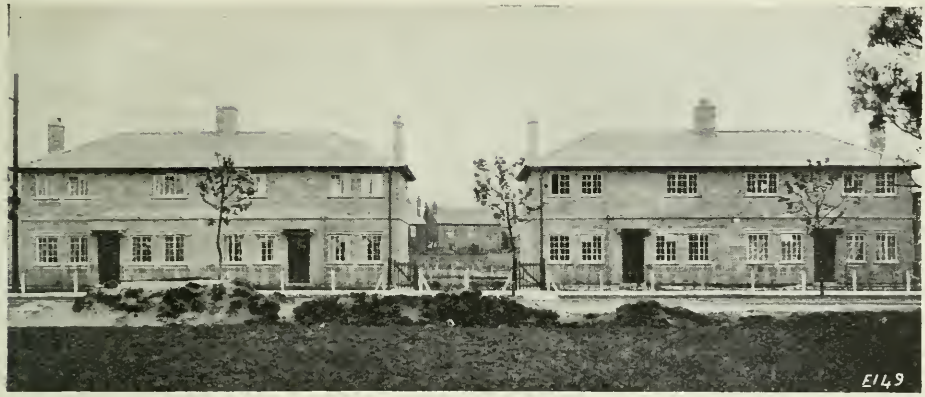


Fig. 7. Ash Lane, Southport.

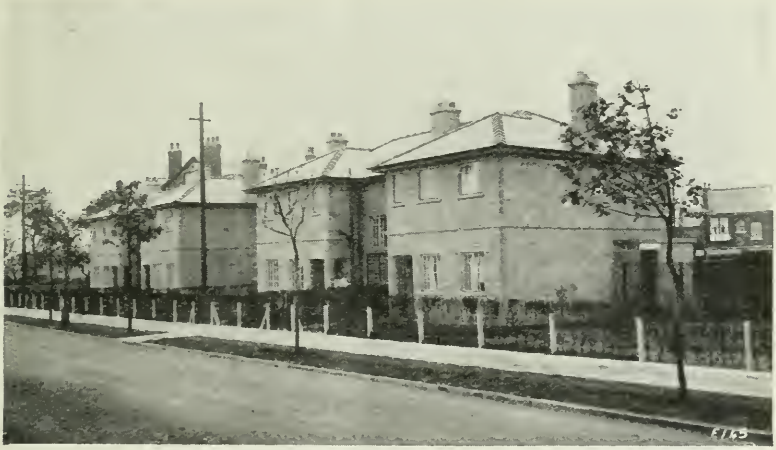


Fig. 8. Ash Lane, Southport.

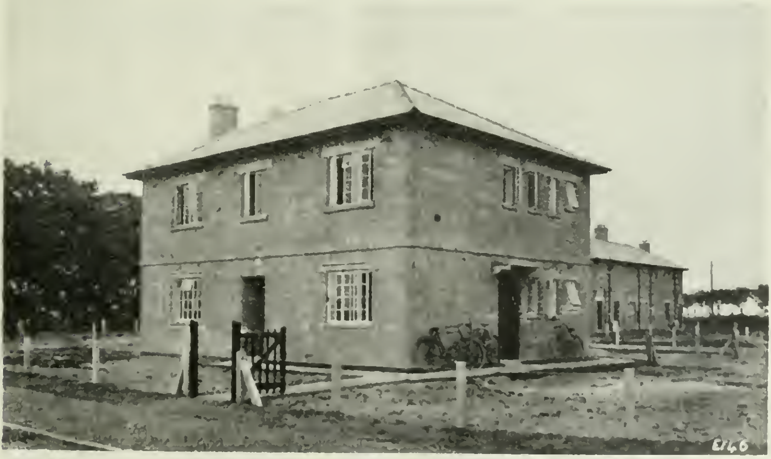


Fig. 9. Pair of Flats.
Southport Housing Scheme.

fitted in the living-rooms and wardrobe cupboards in the bedrooms. Service hatches are fitted in certain types. The sculleries are fitted with a gas boiler and cooking stove, large sink and draining board, and, owing to the extreme hardness of the Southport water, a rainwater tank of 350 gallons capacity is placed outside the house. This tank is constructed in concrete and fitted with a pump. Variation in the schemes has been obtained by the grouping of the blocks and by the treatment of the elevations. Some designs have bay windows, while the roofs are both of tile and slate; similarly both wood and metal casements are used, and certain designs are treated with rough-cast above the plinth level. *Figs.* 1, 7 and 8 are views of houses on the Ash Lane site, *Fig.* 1 being the *cul-de-sac* in the south-west corner of the site. *Fig.* 9 shows a block of flats. *Fig.* 10 is a view of some of the mixing and block-making machinery. The mixers are filled with the raw material from a gantry. The mixture is then passed on to the block-making machines on the right.

A section of an outer wall is seen in *Fig.* 6. It consists of an outer concrete facing block and an inner clinker block with a continuous cavity of 2¾ in. The majority of the floors are of the "Economic" patent design, consisting of hollow concrete blocks reinforced with steel bars. They are covered with mass concrete and finished with a patent jointless flooring, which is finished a red tone and takes a good polish, and is, moreover, a poor conductor of heat, and therefore not too cold for bedrooms. The ground floors are also solid. Most of the aggregate is obtained locally, and of course all the blocks both for floors and for walls are made on the sites.

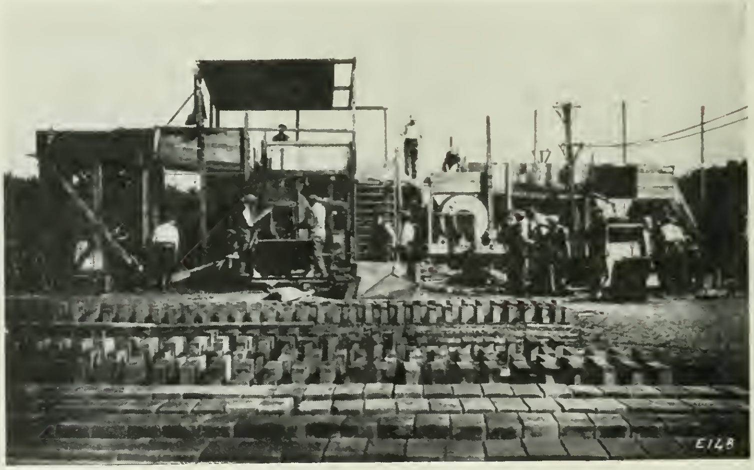


Fig. 10. Mixing and Block-Making Machinery.
SOUTHPORT HOUSING SCHEME.

It will be noticed that the unit in these designs is one yard. The attempt to introduce the metric unit has not been followed on this scheme. It will be noticed, furthermore, that all these houses have pitched roofs. This, in our opinion, is an improvement in appearance to the houses at Braintree, which are earlier work of the Unit Construction Company. Indeed, although the houses are devoid of what are usually termed "features," they are nevertheless extremely pleasant in appearance, their component parts, such as doors, windows, and stacks, being well proportioned, and the size of the blocks being in scale with the size of the building—an important consideration which is often overlooked. The position of the string course, too, is satisfactory, dividing the wall surface into pleasing parts. These may seem small points, but assuredly they are sufficient to mar a design of such simplicity.

In *Fig.* 1 the advantage of the newer form of estate development is seen at its best. It is only necessary to contrast this arrangement of the houses with their long forecourts, their little approach road away from the dust and noise of a street frequented by heavy traffic, grouped in blocks which have some definite relation to each other, with the development prevalent but a few years ago, which consisted, for the most part, of long monotonous terraces facing the road without regard to aspect or privacy, in order to see what progress has been made in the last few years.

One aspect of the scheme is worthy of mention, particularly at the present time. The system has permitted of the employment of unskilled labour on a large scale, and this has had a considerable bearing on its economic aspect. Apart from such reasons, however, concrete has so established itself as a suitable building material for work of this kind that its abandonment would not occur even with a return to normal building conditions; a most unlikely contingency at the present time.

MEMORANDA.

Reinforced Concrete versus Other Materials.—On the Lake Superior Railway, U.S.A., a careful comparison was made, before the war, between the cost of bunkers composed of various materials. The result was that, taking the prime cost of timber at 100, steel came out at 76 and reinforced concrete at 70, and, adding the charges for repairs, interest, insurance, etc., the figures became 100, 62 and 56 respectively. At the present rates the figures would come out still more favourably for the reinforced concrete, it being authoritatively stated that the comparison between timber and concrete works out at 100 and 40 relatively at the present time. For these purposes the latter material would certainly appear to hold the field. On the other hand, in the Lehigh Valley Railroad, concrete, although reinforced, was not considered sufficiently elastic for the paving of a level crossing. It has, however, been extensively used for grade crossings both in the United States and elsewhere, and has proved a successful substitute for other paving.—*Railway Gazette.*

Tunnel Lining with Concrete.—The Connaught Tunnel, on the Canadian Pacific Railway at Glazier, British Columbia, is now being lined with concrete. The tunnel is five miles long, and its altitude (4,000 ft. above sea level) has added considerably to the difficulty of the job; for instance, the nearest city from whence supplies can be obtained is 220 miles distant, and the snowfall in winter is about 40 ft. The concrete mixing and placing plant is carried on two 75-ton trucks coupled together. Storage bins for sand, cement, and gravel are carried on the trucks, together with a water tank, concrete mixer and compressed-air plant for forcing the mix through flexible hose to the forms. The mixer has a capacity of 22 yds. per hour, and the materials are delivered to the hopper above the mixing drum by means of belt conveyors. Fresh supplies of materials are brought up on smaller trucks, from which they are delivered to the plant by belt conveyors. The forms consist of six separate units built up of timber in the shape of a quarter circle, that is, one side and half the roof of the tunnel. These units, each 20 ft. in length, are mounted on wheels, and so constructed that as soon as the placed concrete has set the top plates can be collapsed and the section moved along the tunnel past the other five sections behind which the concrete has been more recently placed. When the forms are in position, the hose is inserted between the side of the tunnel and the top of the form, and concrete forced through at 80 lb. air pressure. The mixer is electrically driven from a plant at the end of the tunnel.

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

RECENT ELECTIONS INTO THE INSTITUTE.

Members :— Brough, George Darroll (from Student).
Bunce, Henry Edgar.
Daniel, Thomas Llewellyn.
Edon-Brown, Herbert.
Griggs, Frank Lewis.

Associate-Members :— Flood, Gerald Maurice.
Logothetis, G. N.
Morton, Harold.
Slate, Walter Frederick (from Student).

CONCRETE AGGREGATES *(Continued).*

The Concrete Institute takes no responsibility for the accuracy of the information supplied.

The following communication has been received for insertion—

June 20, 1921.

Dear Sir—We notice on page 368 of June issue that some particulars are given regarding concrete aggregate at Gloucester (paragraph 39).

We should like to draw attention to the fact that the Barnwood Gravel Pits have been owned by the signatory's Company (not Messrs. Chambers & Co.) since October, 1919. The price shown is not quite accurate, and would read correctly "5*s*. 9*d*. per ton at pit." Perhaps we may add that we own a fleet of Motor Lorries which deliver the material to any site. We are turning out large quantities of fence posts, concrete blocks, paving stones, door hoods, heads, sills, etc., made of this aggregate.

Yours faithfully,

J. W. E. CROSBY.

Manager, The Gloucester Concrete Construction Co., Ltd.

(44) **Horsforth (near Leeds).—**

General description : Sandstone.
Source and Locality of same : Horsforth.
How obtained : Quarrying.
From whom obtained : Messrs. B. Whitaker & Sons, Ltd., Horsforth.
Is available quantity limited ? No.
Present maximum output per day : 200 cubic yards.
Transport facilities : Rail and road. Railway running into quarries.
Is there any provision at or near source for washing or crushing ? Yes.
Price per cubic yard, and where delivered : 8*s*. per ton at quarry.
Is composition uniform ? Yes.
Kind of stone, or coarse material : Sandstone.
Kind of sand or fine material : Sandstone sand. Fine.
Relative proportions of coarse and fine materials : At will, by setting crusher.

Shape of particles : Angular.
Size of particles : approximate percentage that needs crushing to pass ¾-in. screen : All needs crushing.
Impurities present : None.
Source of information : Owners.
General Remarks : Very large quarries, and could increase output to very nearly any extent.
Weight per cubic foot, dry : Solid stone 14 cubic feet to the ton.
Granular analysis : 96·58% silica.
Crushing strength of stone : 552·2 lbs. per square foot.
Proportion of muddy matter : None.

Note.—Messrs. B. Whitaker & Sons furnish the following analysis of sample of screened gravel crushed out of Bramley Fall stone from their quarries at Horsforth :

	Per cent.
Silica	96·58
Ferric Oxide (iron)	0·34
Alumina	1·10
Lime, Magnesia, etc.	0·49
Water (at 212°F.)	0·28
Combined water, organic matter, etc.	1·21
	100·00

THOMAS FAIRLEY,
City and County Analyst,
17 East Parade, Leeds.

Messrs. B. Whitaker & Sons send further the following results of experiments on Bramley Fall stone to ascertain the resistance to thrusting stress of three 6-in. cubes of sandstone :—

Test No.	Name of Quarry and Marked.	Dimensions.	Base Area.	Cracked slightly			Crushed.		
				Stress.	Per sq. in.	Per sq. ft.	Stress.	Per sq. in.	Per sq. ft.
FF.		inches.	sq. ins.	lbs.	lbs.	tons.	lbs.	lbs.	tons.
1403	Messrs. B. Whitaker & Sons, Ltd., Bramley Fall Quarries Marked 2	5·93 5·90 × 5·86	34·57	365,100	10,561	679·2	374,360	10,829	696·4
1404	Do. Marked 3 . .	5·86 5·80 × 5·75	33·35	235,500	7,061	454·1	292,200	8,762	563·5
1402	Do. Marked 1 . .	5·87 5·95 × 5·88	34·98	214,900	6,143	395·0	215,850	6,171	396·8
			Mean	271,833	7,922	509·4	294,137	8,587	552·2

(45) **Hounslow (Middlesex).**—Gravel—25 per cent. loam (R.C.B.).

(46) **Hull (Yorkshire)** Trent gravel and sand, known as Trent Haul-ups or All-ups (no one seems to know the correct spelling), and the description of Thames ballast would apply to this generally, except that the description should actually be " miscellaneous hard sandstone, etc." A good deal of the aggregate used here in the past came as ship's ballast, and until just before the war sea gravel was loaded from the banks outside Spurn, but in diminishing quantities. For specially good work, granite or whinstone chippings are used, the variety depending upon the fancy of the architect or builder. For foundations and rough work, broken brick has been used, or anything in the way of ship's ballast which came along.

This information was furnished in 1919 by Mr. F. W. Bricknell, City Engineer, Hull.

(*These notes are continued on p.* 441.)

THE CONCRETE INSTITUTE.

ANNUAL REPORT.

REPORT OF COUNCIL FOR 1920–21 SESSION.

The present membership of the Concrete Institute is 1,138. During the past year the Institute has shown remarkable vigour in its growth, and the increased public interest taken in its proceedings is a harbinger of further success.

Though the rank of Graduate is one of those constituted under the Articles of Association, it was brought into being only in the period under review, the late war having caused the Council to decide in 1914 to postpone the start of the examinations.

The first examination was held in May, 1920, in London, and in October of the same year an examination was held simultaneously in London and at Salford.

The Council has been successful in arranging additional branches for 1921 by the kind co-operation of Edinburgh University and of University College, Cork.

Educational Lectures.—Owing to the pressure of other work, it was impossible to repeat the successful course of Educational Lectures held during the previous Session; but in February–March, 1922, a course of six lectures on "Economy in Building" is to be delivered by Mr. H. Kempton Dyson, M.C.I.

Bronze Medal.—As a result of a ballot among Members of Council, the bronze medal for the best paper read in the 1919–20 Session was awarded to Dr. J. S. Owens, F.G.S., F.R.G.S., V.-P.C.I., for his paper entitled "The Attrition of Concrete Surfaces Exposed to Sea Action."

Generally.—A number of interesting visits of inspection were arranged during 1920, and in connection with the Building Trades Exhibition held in April, which was held at Olympia, Kensington, the Institute arranged for some lectures to be given at the Exhibition.

Sub-Committees.

Reinforced Concrete Practice Standing Committee.—The most important work of the Committee during the year under review consisted in the drafting of a standard specification for concrete blocks and also in formulating recommendations for amending as may be necessary the R.C. Regulations of the London County Council. Both these subjects have been relegated to sub-committees; in regard to the Regulations the report will be made to this Committee and the Science Committee acting as a joint Committee. Before reporting to the Council, the joint Committee will invite expressions of opinions upon the subject from the Royal Institute of British Architects, the Institution of Civil Engineers, and the Surveyors' Institution.

Science Standing Committee.—The Committee are dealing with the question of coefficients of friction and adhesion between steel and concrete; the subject of rendering concrete impermeable has also been kept under notice by the Committee, and a report will be drawn up as a result of the paper read by Mr. E. S. Andrews, B.Sc. (Eng.).

Furthermore the Committee are about to consider the report of the sub-committee upon the use of high-tension steels in reinforced concrete.

THE ANNUAL MEETING.

The Annual General Meeting of the Institute took place on Thursday, May 26, at Denison House, Vauxhall Bridge Road. The President, Mr. E. Fiander Etchells, took the chair.

The Annual Report was presented and its adoption moved and seconded, and it was unanimously adopted.

Bronze Medal.—The President then awarded the Medal of the Institute for the best paper read during the previous session to Dr. J. S. Owens, F.G.S., etc. In doing so, he said that Dr. Owens' paper on "The Attrition of Concrete Surfaces Exposed to Sea Action," presented during the Session 1919–20, was an exceedingly able one, and had meant much research on the part of the author. After some further remarks Dr. Owens received the medal amid applause.

THE MODULUS OF ELASTICITY OF CONCRETE.

By Prof. F. C. LEA, O.B.E., D.Sc., M.Inst.C.E.

The following is an abstract from a Paper read at the One Hundred and Fourth Ordinary General Meeting of the Concrete Institute on Thursday, April 28th, 1921, at 7.30 p.m. Mr. E. Fiandar Etchells, President, took the Chair. We are only able to give a very brief abstract from this valuable paper, which included a large number of diagrams and tables, and some Appendices. Full copies of this Paper can be obtained from the Concrete Institute.

Engineering theories are only justifiable in so far as they are consistent with experience or can be directly verified by experiment, and it is of the utmost importance that the fundamental assumptions underlying the theory of elasticity and the theory of structures should be from time to time critically examined. In all calculations relating to reinforced concrete structures the all-important fundamental assumption is made that the ratio of the modulus of elasticity of steel to the modulus of elasticity of concrete is known, and for a particular structure is constant for all stresses. Mild steel, whether in compression or in tension, gives a stress-strain curve which, within the so-called elastic limit, approximates very nearly to the ideal straight line, or, in other words, obeys almost perfectly Hooke's law. Further, the value of the modulus of steel (Es) is not a very variable quantity. It is doubtful if, for the kinds of steel used in reinforced concrete work, the modulus varies more than 5 per cent. from one sample to another, and the modulus of elasticity in tension probably does not differ from that of the steel in compression by more than 5 per cent.

The ordinary theory of beams and long columns assumes the ideal elastic behaviour of material, and in the case of properly designed steel elements experiment shows that within certain limits of stress the ideal assumptions are justified.

Good steel is known to consist of crystals of ferrite surrounded by pearlite; and consistent with the discontinuity between the crystals, its structure can be said to be very homogeneous as compared with concrete, which is made up of three such variable materials as cement, sand or other fine material, and large aggregate. It is hardly to be expected that such a conglomerate will have elastic properties as perfect or as constant as the more homogeneous steel, and it becomes important therefore to determine :—

(1) The form of the stress-strain curve for concrete and thus the value and possible variation of the modulus of elasticity.

(2) What are the possible limits of error in making assumptions which are not ideally justified by experiment.

In making calculations relating to the design of beams the tensile strength of the concrete in tension is generally neglected. In columns, unless there is eccentric loading, the material is in compression.

It would appear, therefore, only necessary to determine as accurately as possible the stress-strain curves for concrete in compression, from which the ratio Es/Ec (which the theory demands to be known) can be obtained. As a check, however, it is desirable that elastic tests on beams should also be made, not only to determine the deflections produced under certain conditions of loading, but to determine the actual strains assumed, and the position of the neutral axis of the beam, as experimentally determined, compared with that given by the theory.

Another and incidental, but not unimportant, result of such inquiry will be that some light may be thrown upon the problem of the degree of uniformity of distribution of stress across the section of a strut or on lines parallel to the neutral axis on the section of a beam. The present paper gives the results of experiments that have been carried out recently at Birmingham. They are by no means complete, as owing first to the war and secondly to the very heavy pressure upon time and conveniences for experimental work since the war, progress has not been so rapid as might have been desired, but the experiments have involved a good deal of labour which could not have been carried out without the enthusiastic co-operation of research students.

Definition of the Modulus of Elasticity of Concrete. — Before the modulus of elasticity of any piece of concrete can be stated, it will be shown in the sequence that it is necessary to know, not only its composition and the quality of the materials in the concrete, but also its previous history as far as loading is concerned. Thus it will be seen that the very data required for the calculations in connection with a particular class of concrete can only be known within a certain degree of approximation.

Here follow a series of stress diagrams relating to different concretes with a critical examination of them. These stress strain curves were obtained by a special compressometer shown in the accompanying illustration, which shows a general view of the compressometer fitted to a 4 in. × 4 in. concrete block 15 in. long. At each end of a measured length of 8 in. two aluminium alloy angles are bolted to the specimen. Long bosses are cast on the angles through which are drilled and reamered $\frac{1}{2}$ in. diameter holes. The two top angles were drilled and reamered while bolted together. The bottom angles were similarly treated. For assembling the angles on the specimen there is a $\frac{1}{2}$ in. diameter assembling rod with milled nut N fitting into a conical hole in each of the angles. After clamping the angles on to the specimen, this rod is withdrawn through the slot S. The angles when clamped form the top and bottom platforms of the compressometer.

To understand clearly the principle of the instrument the accompanying diagram of a concrete block having ZZ as its axis should be considered. When such a block is loaded in a testing machine it is very difficult to ensure true axial loading, and even if this is assumed it is doubtful if there is a uniform stress over the cross-section of the block.

Suppose now as the block is compressed the true lengths of ab and a_1b_1 are measured. Then, assuming aa_1 and bb_1 remain in a plane the mean between these gives the change in length of ZZ. If, therefore, the load is assumed to be in the plane of YY but not in the plane of XX the strain in ZZ will be obtained correctly. If, now, the load is not in the plane of YY there will be bending about the axis YY, and since aa_1b_1b is in the plane of YY the mean of ab and a_1b_1 will give again the strain along the axis. It should be noted that unless the concrete obeys Hooke's law the assumptions will not be rigidly justified; and as part of the experiment is to find how far Hooke's law is obeyed by concrete it will appear that an instrument which measures a_1b_1 and ab is not really perfect. It, however, will give results probably sufficiently accurate.

In the actual instrument there is an optical level at each side of the specimen, by which the changes in the lengths of a_1b_1 and ab are measured as the block is stressed.

SUMMARY OF STRENGTH RESULTS.

The results of the tests may be summed up as below:—

Proportion of Cement by vol. of Wet Concrete.	Ratio by vol. of Sand to Stone.	Crushing Strength at 28 days. Lb./in.^{2}		
		D.B. Gravel	H. Quartzite.	Rowley Rag.
20 per cent.	1 : 1	—	1,800	1,800
20 ,,	1 : 1$\frac{1}{2}$	2,500	2,300	2,100
20 ,,	1 : 2	2,500	2,500	2,500
20 ,,	1 : 2$\frac{1}{2}$	2,500	—	—
25 ,,	1 : 1	—	2,500	2,600
25 ,,	1 : 1$\frac{1}{2}$	3,000	3,100	2,700
25 ,,	1 : 2	3,200	3,200	3,200
25 ,,	1 : 2$\frac{1}{2}$	3,300	—	—

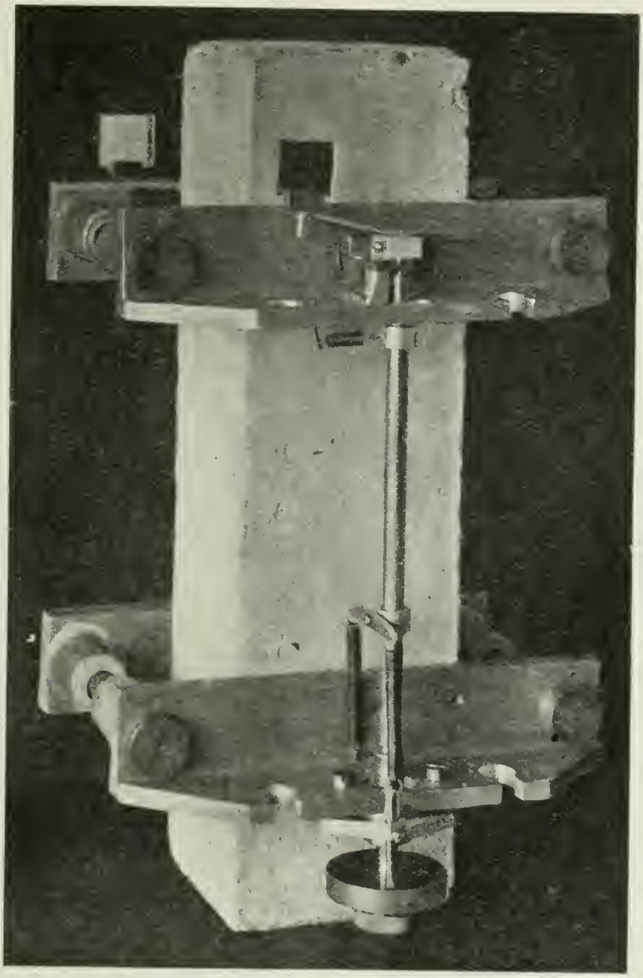
It is clear from these results that with the two stones (Quartzite and Rowley Rag) as aggregates, the ratio of sand to stone as 1 : 2 is the best; while with the D.B. gravel as aggregate there is but little difference between the 1 : 2 and 1 : 2$\frac{1}{2}$. With the ratio of 1 cement to 2 sand, all three aggregates give the same strength.

Experiments on beams to determine the modulus of elasticity by measuring the strain in the beam showed that (1) the modulus of elasticity of concrete is a very variable quantity, but for a particular mixture the modulus can be fairly definitely obtained by determining the slopes of the third or fourth loading stress-strain curves taken from blocks of concrete three months old, and that the values so obtained will approximate very closely to those determined from strain tests on beams.

(2) If such a value can be given to the modulus of elasticity of concrete, then the neutral axis as determined by calculation will agree fairly well with the experimental position of the neutral axis, and thus the stresses to be expected can be estimated with reasonable precision.

The real difficulty is in anticipating the value of the modular ratio, but, as will be seen presently, a comparatively large error in the assumption of this ratio only affects the final stresses in the beams or columns to a much less degree than the error in the assumption.

Unequal Distribution of Stress in Concrete.—The compressometer tests on columns and also the bending tests on beams show clearly that it is very difficult indeed to ensure uniform distribution of stress in concrete. The column specimens were hand ground at the end to make them sit as smooth as possible, and they were then loaded through a spherical seating.



Compressometer on Prism.

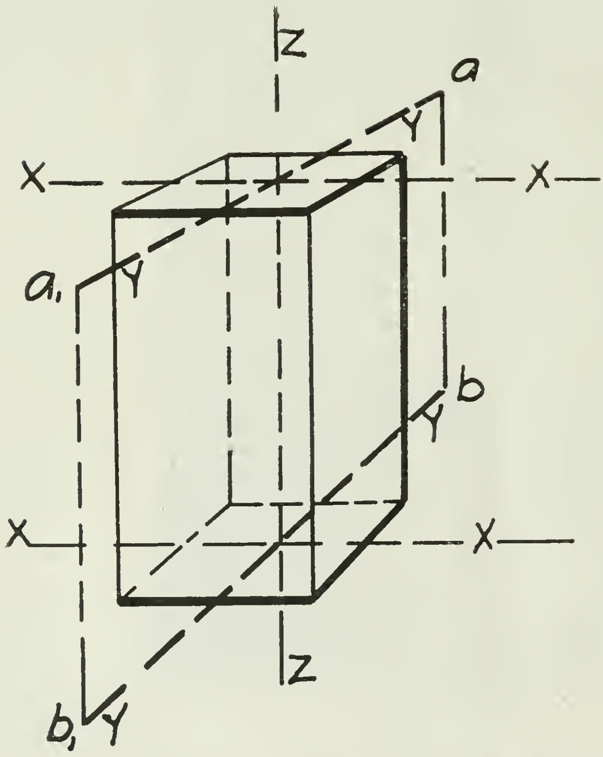
Reproduced by courtesy of the Concrete Institute.]

Table 8 shows the typical difference in the recorded strains on the two sides of the specimen on the second loading of the specimen. During the first loading the differences of the strains on the two sides of the specimen were much greater than during the second loading.

TABLE 8.

Load in lb.	Stress in lb.	Decrease in Length in $\frac{1}{1000}$ in.		
		Back.	Front.	Mean.
1,660	101	5·78	3·08	4·43
3,240	198	7·17	4·17	5·67
5,260	321	9·15	6·94	8·04
7,140	437	12·10	10·52	11·31
8,580	524	13·95	12·74	13·34
9,840	602	15·95	14·82	15·28
11,470	701	18·32	17·35	17·83
12,960	793	20·68	19·60	20·14
14,560	891	22·90	22·00	22·45
16,270	995	25·40	24·70	25·05

Taking a difference of load of 995—321 = 674 lb. the strains at the back give a nominal value of *Ec* of 3·31 and the strain at the front a nominal value of *Ec* of 3·03, or a difference of 9 per cent. As might be expected, at small loads the inequalities are greater than at the large loads.



[*By courtesy of the Concrete Institute.*

In the beam experiments the differences of strain at the same distance from the neutral axes on the two sides of the beam were as great as 16 per cent. This can only be accounted for by larger stresses on one side of the beam than the other, due to the non-homogeneity of the concrete or perhaps partly due to the eccentricity of the reinforcement. If the reinforcement is slightly displaced, or the adhesion is not uniform on the bars, excess strain may be set up in one side of the beam.

It would appear, therefore, that in designing concrete columns and beams, however carefully these are to be loaded, an allowance for a possibility of stresses from 10 to 20 per cent. above the mean calculated stress, as given by the ordinary formulæ, should be made.

APPENDIX 2 (*Abbreviated*).

Conclusions from the Compressometer Tests.—As has been mentioned before, the results show that the mixtures in which the ratio of sand to stone are 1 : 1 and 1 : 1½ are not to be recommended. We have, therefore, only the mixtures with ratio of sand to stone as 1 : 2 left for each of the coarse aggregates. The properties of these mixtures may be summed up as below :—

SUMMARY OF RESULTS.

Coarse aggregate.	Proportion by vol. % and ratio of sand : stone.	Proportion by vol. cement : sand : stone.	Crush stress at 28 days. Lb./in.^{2}	E in million lbs./in.^{2}	Approx. Wt. Lbs./c.ft.
D.B. Gravel . .	25% 1 : 2	1 : 1·41 : 2·82	3,200	3·0/3·8	147
H. Quartzite . .	25% 1 : 2	1 : 1·48 : 2·97	3,200	3·2/3·5	146
Rowley Rag . .	25% 1 : 2	1 : 1·56 : 3·13	3,200	3·0/3·9	150
D.B. Gravel . .	20% 1 : 2	1 : 1·83 : 3·66	2,500	3·1/3·3	146
H. Quartzite . .	20% 1 : 2	1 : 1·95 : 3·90	2,500	2·4/3·3	145
Rowley Rag . .	20% 1 : 2	1 : 2·07 : 4·14	2,500	2·3/2·9	149

We have here two mixtures of concrete, one with 25 per cent. and the other with 20 per cent. cement; which is the more economical when used in concrete and reinforced concrete works ?

With regard to the relation between strength and percentage of cement, the following example will make it clear that the 25 per cent. cement mixture is the more economical, at any rate for plain concrete.

To find the volume of concrete required for a short column of length L'' to stand a load of 2,500 lb.—

(1) with 20% 1 : 2 mixture — crushing stress 2,500lb./in.^{2}
Area required = 1 sq. in.
Volume = L cu. in.
Vol. of cement required = 25% = $0{\cdot}2L$ cu. in.

(2) with 25% 1 : 2 mixture — crushing stress 3,200 lb./in.^{2}
Area required = 2,500/3,200 = 0·8 sq. in.
Volume = $0.8L$ cu. in.
Vol. of cement required = 20% = $0{\cdot}2L$ cu. in.

In the latter case, whilst the amount of cement required is the same the volume of concrete is 20 per cent. less than that required in the former case, thus effecting economy.

Taking the factor of safety as 4 for reinforced concrete work, the following may be taken as the properties of the two concretes :—

	Allowable compressive stress 1 lb./in^2	Ec 10^6lb./in^2	Es/Ec
25% cement concrete	800	3·75	8
20% cement concrete	625	3·00	10

DISCUSSION.

Mr. F. E. Wentworth Sheilds, O.B.E., in proposing a hearty vote of thanks to Professor Lea, and expressing appreciation of the research work carried out by him, said that like many researches of this kind, a good deal had to be done before one could see what practical use was going to be made of it, but Professor Lea had suggested one practical outcome, and that was, he had told them that they, perhaps, ought to alter their sacred 15, which they had stood by for so many years.

Mr. H. J. Deane, M.Inst.C.E., in seconding the vote of thanks, said it had been a great surprise to him to see what an extraordinary hysteresis curve was obtained from the results of the experiments, and while not daring to criticise the paper, because he was quite out of his depth, he would like to say one or two things with regard to the general question of stresses. Of course, the whole matter of determination of the neutral axis depended on the ratio of the moduli ; but the main thing the structural engineer had to deal with was the question as to whether his structure was going to stand up or not. There was no doubt that they could not do without theory, but in spite of all, when they considered the sacred 15, he knew quite a number of reinforced concrete structures that he was sure had been designed on the 15, and they were still standing. Another thing to be considered in connection with the ratio of the moduli was the question of what would the concrete stand. They made certain assumptions ; they said they were going to make concrete of such and such a mix, and that mix was going to give a certain ultimate strength at the end of a certain time. The difficulty was what was to be taken as a reasonable ultimate strength. The factor of safety was their salvation every time, and the one generally adopted was 4 to 1, but if they assumed that some of their concrete was only half as strong as was anticipated, the factor of safety was 2 to 1, and very near breaking point. If a concrete is being aimed at which will break at 3,500 lb. per square inch we must get within 10 per cent. on either side of the mean ; to-day it is not possible to get anything like it.

Dr. Oscar Faber, in a written contribution to the discussion, referred to the question of plasticity, which seemed to be ignored in the paper, and which, in his opinion, might radically alter the conclusions to be put on the results of the researches. The question of time did not appear to have entered into the author's experiments, except in so far as it affected the age of the specimens. It appeared, however, that concrete, according to certain recent tests, might not be an elastic substance in the ordinary sense at all, even for comparatively small compressions, but that the amount of the compressions went on increasing with time. In other words, that concrete gradually yielded and behaved as a body with both elastic and plastic properties. In a building the stress applied to a column continued for years, and if concrete showed any plasticity, the effect of deformation would depend very greatly on the length of time during which the specimen had been subjected to stress. Tests described in a paper read before the American Concrete Institute by Mr. MacMillan in February of this year showed that deformation came under three heads: (1) shrinkage, (2) elastic deformation, (3) gradual yielding in time. As to the first, it appeared that concrete gradually shrank about 0·5 per cent. of its length in about sixty days, after which it was comparatively negligible. Taking the elastic modulus of steel as thirty million, the generally accepted figure, it followed that in a reinforced concrete column, owing to this shrinkage, the steel would have a stress of 15,000 lb. per square inch before the concrete received any stress whatever. Therefore, the effect of shrinkage was to subject the concrete to tension and the steel to compression, and when the load was first applied the effect was gradually to neutralise the tension in the concrete and still further increase the stress on the steel, and when sufficient compression had been applied it brought the tension in the concrete back to zero, and the compressive stress on the steel should, on these figures, be about 15,000 lb. per square inch. As to the elastic compression, Professor Lea's results agreed in the main with other experiments conducted in the same general way. The writer here referred to American investigations reported on in 1916 by Messrs. Fuller and More, by Mr. E. B. Smith (in 1917), and by Mr. A. R. Lord. He thought that before any conclusions were drawn from the results of elastic experiments such as those described by the author, the question of yielding must receive a great deal more consideration than it had hitherto been given. Though Professor Lea had found, as a result of his short time tests, that the modular ratio was nearer 10 than 15, it appeared that as a result of this yielding stress in a column was gradually being transferred from the concrete on to the steel, and after a year or so the deformation approximated to a modular ratio of 70. This aspect of the problem was one of the very greatest importance, and apparently we did not yet know the limit of this yielding. It appeared to him that in all probability a column left for a long time under load would gradually transfer stress on to the steel until the steel reached the yield point, and the rest of the stress would then be carried on the concrete. He fully understood that this was a revolutionary kind of theory to put forward, but he did not see how any other conclusion could be come to when the effect of plastic yield, as actually measured on many different specimens, was taken into account.

Mr. Percy J. Waldram referred to some experiments on the modulus of elasticity carried out by the French Government some years ago, in which a large number of beams were tested by very similar methods to those described by Professor Lea, not as regards extensometers or compressometers, but as regards the theoretical point of measuring the loads already in the beam, and compiling therefrom an interesting diagram showing the actual position of the neutral axis. Those experiments were almost entirely confined to what the author had referred to as poor concretes. From a somewhat rapid investigation of the concretes of which he had given the results, it would appear that he had been testing rather richer concretes than those subjected to test by the French Government, and that, therefore, formed a very valuable completion of the original work carried out in the early days. He would like to draw attention to one particular point. The reduction of the modulus of elasticity from, say, 15 to any figure like 10 or 8 pre-supposed that the stiffness of the concrete would be more nearly approaching the stiffness of the steel, and therefore the concrete, he took it, would be assuming to itself a large proportion of the joint load shared between the two in a column or a double reinforced beam. As it picked up a great proportion of the load, it naturally reached its limit of strength more quickly. Therefore, a beam which depended for its strength on the strength of the concrete was, as pointed out, weaker than it would be expected to be if a modulus of 15 were used where 8 should be used. In how many beams was the strength of the concrete the criterion of the strength of the beam? Did not that presuppose that the designer was using quite an insufficient depth, and was it not a fact that the most economical beam was one with a low percentage of tensile reinforcement, and therefore depended on the stress on the steel and not on the stress on the concrete?

Mr. W. Smith (National Physical Laboratory) said that at the Laboratory tests on concrete had lately been carried out for the Office of Works. So far as they had gone they had found that the behaviour of the concrete was exactly as indicated by Professor Lea in every respect.

Mr. H. Kempton Dyson : Dr. Faber had referred to the effect of time in loading a specimen producing increased deformation. The author had also shown that the second and third times of loading gave a greater deformation, and further, that when the stress was increased considerably—he did not mean 250, or 600 lb. per square inch, but over half the ultimate strength of the concrete—an appreciable increase in the deformation was noticed while the experiment was going on. In experiments which he himself had carried out some years ago it was seen that when the stress on the specimen was considerably increased there was a great increase of strain if the load were left on, and that made it difficult to determine what was the real elastic modulus at high stresses. Some of the experiments referred to by Dr. Faber might come under that heading, that they related to concretes tested with a very high stress. He did not think the time effect was so noticeable on low stressed concrete, but some experiments showing the effect of time would be useful. He was not particularly persuaded that the modular ratio was really needed in their calculations. As it was such a variable function it would be rather nice if it could be got rid of. An interesting fact brought out in the paper was that the modulus of elasticity increased slightly with the stress in the twelve months blocks. That was quite different to what was expected. There was another remark made by the author which he himself could not quite reconcile with experiments. It was said that the modulus of elasticity was roughly 1,000 times the crushing stress in lb. per square inch. The author had shown in the diagrams, however, that when a concrete was tested at a later date, twelve months' instead of three, although the strength of that concrete was greater, the modulus was no greater; if anything, it was less. The modulus did not seem to go directly as the increase in compressive resistance of the concrete. As to the tests on beams, they seemed rather different from those of other experimenters. It would seem as if the author located the neutral axis by experiment, and then worked back by the ordinary formula to find the modular ratio which would place the neutral axis in that position, and then computed the stress in the steel and that in the concrete. It is not known that the stress in the concrete or in the steel is as calculated. If the strains in the steel were measured they could determine what the stress in the steel was. They had got, however, the strains that were measured in the concrete, and by comparison with compressometer readings on the prisms he thought it might be found that the stress in the concrete from the other strain readings was very different from those computed figures. He did not think Table 7 in the paper was at all conclusive as to the value of the modular ratio that should be taken with the ordinary theory. For instance, the surprising thing about it was that as the load increased on the beam the modular ratio dropped. The general view was that, as shown by the stress-strain diagrams, as the stress on the concrete increased the modulus dropped. The steel, up to the yield point, remained with a constant modulus. If the elastic modulus of the concrete were getting smaller as the stress increased, and as the modular ratio was the modulus of the steel divided by the modulus of the concrete, the modular ratio ought to increase as the loading continued.

Mr. Alfred S. Grunspan, A.M.Inst.C.E., etc., asked whether the variation of the modulus in concrete had been studied with varying sizes of aggregate. As to the curves given in Fig. 2 of the paper, it seemed that these were convincing evidence that concrete was far stronger than a great many people thought. The fact that there was a big hysteresis load showed that concrete absorbed work when it was stressed, and work put into the concrete, therefore, made it stronger. He would like to know whether any experiments had been made or contemplated with a load suddenly applied and quickly removed at the same time, which very often happened on bridges. He, personally, thought that concrete under such conditions behaved better than ordinary steel girders—a properly designed concrete beam. The conclusion seemed to be that the reversible loads were very good for concrete. It reduced the permanent set, and made it more elastic.

THE LECTURER'S REPLY

Professor Lea, in replying to the discussion, said that he did not want to draw any definite conclusions from his experiments, but rather to leave the data to the members of the Institute for them to put any interpretations upon them they liked. Regarding the second part of the paper, in which he dealt with the definition of the modulus of elasticity in concrete, he was very careful to point out that this depended on the previous history of the concrete! That was a most important fact. Dr. Faber, in his contribution, was only touching a fact probably fundamental to a great many other subjects. He (Professor Lea) had pointed out that within the time during which the experiments were carried out certain results were obtained. If the experiments had been spread over a period of twelve months he would certainly have obtained something different, and therefore, within the definitions he had given and the statements he had made he thought his data could be taken as being correct. As to whether Dr. Faber had really put his finger upon the real fact, that the creep in concrete at the ordinary stresses met with in structures was so tremendously important as he had indicated, he would not like to be sure. It was pretty certain, however, that time was a most important factor in all materials. Dr. Faber's suggestions were very important indeed, but it remained for the future to know how important they were. Many structures had been built on the old theory that the modulus of elasticity was practically that obtained by ordinary experiments under ordinary time loadings, and those structures were still standing, and were apparently very safe. Replying to Mr. Grunspan, Professor Lea said experiments had been started in the direction suggested.

SECRETARY'S NOTES *(continued from page 433)*.

Reinforced Concrete—Hastings Ladies' Baths.—Mr. H. T. Richardson, Architect, and Mr. E. A. W. Phillips, M.Inst.C.E., M.C.I., Consulting Engineer, are engaged in the repair of the ladies' baths in the Hastings Baths. The existing decking is 18 in. thick, and is to be retained and permanently shored with reinforced concrete; subsequently the existing iron girders and columns are to be removed.

The condition of the existing iron girders and columns, and the method of shoring up the deck, will be of interest to our members; and thanks to the kindness of Messrs. Richardson and Phillips, it will be possible to arrange a visit during the holiday months. Those of our members who expect to be in Hastings during July or August, should communicate with the Secretary of the Concrete Institute, Denison House, 296 Vauxhall Bridge Road, S.W.1, stating the period during which they expect to be in Hastings.

THE AMERICAN CONCRETE INSTITUTE.

REVIEW OF RECENT AMERICAN PAPER ON REINFORCED CONCRETE COLUMNS.

By OSCAR FABER, O.B.E., D.Sc.

THE Paper was presented on February 14th-16th to the American Concrete Institute by Franklin R. McMillan, Assistant Engineer, Turner Construction Company, which, whether or not we agree with the results arrived at, brings out clearly some very interesting points of great importance which are certainly well worth studying. The author confines his discussion to columns reinforced with both longitudinal steel and with closely spaced spirals.

He first investigates a considerable number of the published tests on columns, such as—those by Professor M. O. Withey (Bulletin 466, University, Wisconsin) and those of the American Concrete Institute, and comes to the conclusion that while the various tests agree fairly well as regards yield points they disagree badly in regard to ultimate loads.

He points out that all the tests in Professor Withey's series agree pretty well with the following formula :

$$\frac{P}{Af'_c} = 1 + 21p + 39p' \quad \dots\dots\dots \quad (1)$$

In which P = Ultimate load on the column.
A = Total core area = Concrete area plus steel area.
f'_c = Ultimate unit strength of the concrete.
p = Longitudinal steel ratio.
p' = Lateral steel ratio.

The average value of f'_c for the series was 2,000 lb. per sq. inch ; introducing this value the equation becomes :

$$\frac{P}{A} = 2{,}000\ (1-p) + 44{,}000p + 78{,}000p' \quad \dots\dots\dots \quad (2)$$

Now the coefficient of p in the second term of the second member of this equation is almost exactly the yield point stress of the longitudinal steel (see note on *Fig.* 1), letting this be f'_s and introducing $f''_s = 96{,}000$, the yield point stress of the spiral steel, the equation may be written :

$$\frac{P}{A} = f'_c\ (1-p) + f'_s p + \cdot 81 f''_s p' \quad \dots\dots\dots \quad (3)$$

The Concrete Institute tests lead to the formula :

$$\frac{P}{Af'_c} = 1 + 11p + 60p' \quad \dots\dots\dots \quad (4)$$

Substituting as before the value of f'_c, f'_s and f''_s, in this series 3,000, 35 700 and 62,000 respectively, the equation becomes :

$$\frac{P}{A} = f'_c\ (1-p) + f'_s p + 2 \cdot 90 f''_s p' \quad \dots\dots\dots \quad (5)$$

It will be noticed that equation (4) gives much less importance to the longitudinal reinforcement and much more importance to the lateral reinforcement than that derived from Professor Withey's tests (Equation 1), but when the increased strength of the Concrete Institute tests is allowed for the two equations become identical (see (3) and (5)), except for the coefficients of the last term, which relates to the spiral binding, where the disagreement is very great.

As regards the yield point stresses in the columns, Professor Withey has shown that the yield points of the columns were given by the equation

$$\frac{P'}{A} = f'_c(1-p) + f'_s p \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (6)$$

in which P' is the load on the column at the yield point and the other letters the same as before, from which it will be noticed that the result is the same as the ultimate load with the exception that the last factor in the ultimate load formula which depended on the strength of the binding has completely disappeared, or in other words—that the binding has not come into play until after the yield point was reached. Another lesson to be derived from this last formula is that the yield point in the column is reached when the concrete reaches its ultimate stress, and the longitudinal reinforcement reaches the yield point of the steel. The author concludes from this that at high stresses the steel takes an increasing proportion of the load until its yield point is reached, after which the stress in the steel remains practically constant and that in the concrete gradually increases until the ultimate is reached, when the yield point of the column as a whole takes place and any remaining strength is derived from the binding.

The author then discusses at some length the plasticity of concrete, which enables this remarkable transference of stresses to take place, and results of tests on columns in buildings are given in which apparently the unit compression in the concrete of the columns, i.e., the shortening per unit length, goes on increasing steadily even when the load remains constant and over very long periods. Thus in the case of a certain column marked No. 19 the compression is about ·0005 after 120 days, ·0008 after 240 days, ·00094 after 360 days, ·0011 after 480 days and ·00125 after 600 days; the remarkable thing being, of course, that the concrete was shortening at nearly as great a rate at the end of nearly two years as it was when the tests began. Now obviously the shortening of the concrete must be accompanied by a transference of the loading from the concrete on to the steel, and these observations appear to be worthy of very careful consideration because the deformation represented at 600 days is equivalent to a steel stress of something over 36,000 lb. per sq. inch. It is a pity the observations cease at this point, because as this figure probably represents approximately the yield point of the steel it would have been particularly interesting to see what happened beyond this point.

This question of plasticity is also partly bound up with the question of the initial shrinkage which takes place when concrete sets in air, and a large number of tests by A. C. Janni indicate that the unit shrinkage, that is to say, the shrinkage per unit length, gradually increases up to about ·0005 in about 60 days and thereafter remains sensibly constant, though increasing very slowly with ups and downs, for a period of a year or two. This shrinkage obviously also has the effect of transferring stress from the concrete on to the steel, and the author shows how a formula can be derived in which this is taken into account.

He then proceeds to show that, although when concrete is stressed at first it behaves as though it had an elastic modulus of about two million, which gives the well-known value for the modular ratio of 15, the deformation gradually increases over a period of two or three years, and that at the end of this period the deformation is approximately double that measurement at the end of 50 days, and he therefore adopts a value of 30 for the modular ratio instead of the lower values in common use.

The result of all his labours is to produce his working formulæ:—

$$P/A = 333(1+29p) + 15{,}000p \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (7)$$

which is derived, according to the author, from taking the modular ratio as 30, the unit shrinkage as ·0005 and fixing the steel stress at 25,000 lb. per sq. inch. Although the author does not put it in this form, it would appear that a simpler form would be to give the total load on the column equal to 333 lb. per sq. inch on the concrete, and 25,000 lb. per sq. inch on the steel.

It will be noticed that the formula contains no item for the transverse steel, but the author mentions that it is recommended that the longitudinal steel be limited between 1 and 8 per cent. and that closely spaced spirals be required not less than one quarter of the longitudinal steel and in no case less than half per cent., and the author states that for longitudinal steel a deformed bar of proper design having a yield point not less than 45,000 lb. per sq. inch should be required, but indicates that if lower values are taken the working stress in the steel should be reduced proportionately. It is obvious that the factor of safety on the steel is $\frac{45{,}000}{25{,}000}$ which is 1·8, while that on the concrete is $\frac{2{,}000}{333}$ which is 6, if we use a concrete with an ultimate stress of 2,000. It is obvious, therefore, that the formula gives very high factors of safety when the percentage of reinforcement is low, and very small factors of safety when the percentage is high, and the steel plays a much more important part, and the author claims this as a great advantage of his formula, in view of the fact that the concrete is probably the less reliable material of the two. He also points out that the quality of the concrete finds no place in his formula, and explains this by observing that the shrinkage is probably greater for richer mixtures than for poor ones, and that the effect of this will probably be to throw still more load on to the steel and less on to the concrete.

The Paper is certainly well worthy of study by all who wish to follow closely some of the complicated reactions actually taking place inside a concrete column, and the author has brought forward very clearly, and collected in a useful form, data on the subject of shrinkage and the increase of deformation with time, but one would hesitate very strongly to adopt his formula until a great deal more work has been done than is at present the case. It is clear that the result of his formula is to give very great value to the steel in a column, and very little value to the concrete. This may be noticed from the following.

In the formula, as adopted, the ratio of steel stress to concrete stress is 15, whereas in the author's formula the ratio is clearly $\frac{25{,}000}{333}$ which is 75, or five times as much. In other words, the relative value of steel and concrete is increased by five times as much by the author over and above what has been taken in the past, which would certainly require very full justification before it could be accepted. An obvious weakness of the author's formula is also that the quantity of lateral reinforcement finds no place in it, although the author himself states that it is only applicable to columns containing longitudinal reinforcement and a closely spaced spiral. The same result as the author's formula is really achieved by taking the ordinary formula in common use and substituting 75 for the modular ratio instead of 15, and in this connection it is somewhat interesting to note that the tendency recently has been rather in the direction of taking modular ratio less than 15 instead of greater. For example, the French Regulations adopt a lower value, and the London County Council Regulations, in their present form, adopt a value of 15 when the concrete stress is taken at 600, and a corresponding lesser value when the concrete stress is increased either by using richer mixtures, or by the use of lateral reinforcement. We now have a proposal, the net result of which is the same as if we increase it to 75, and the net effect on the mind tends to be—that while all the facts which the author brings forward are worthy of very careful study, we should do well to accept the simple figure of 15, while the French adopt a lower one, and the Americans a higher one, until we have something fairly authoritative causing us to modify this either in the one direction or the other.

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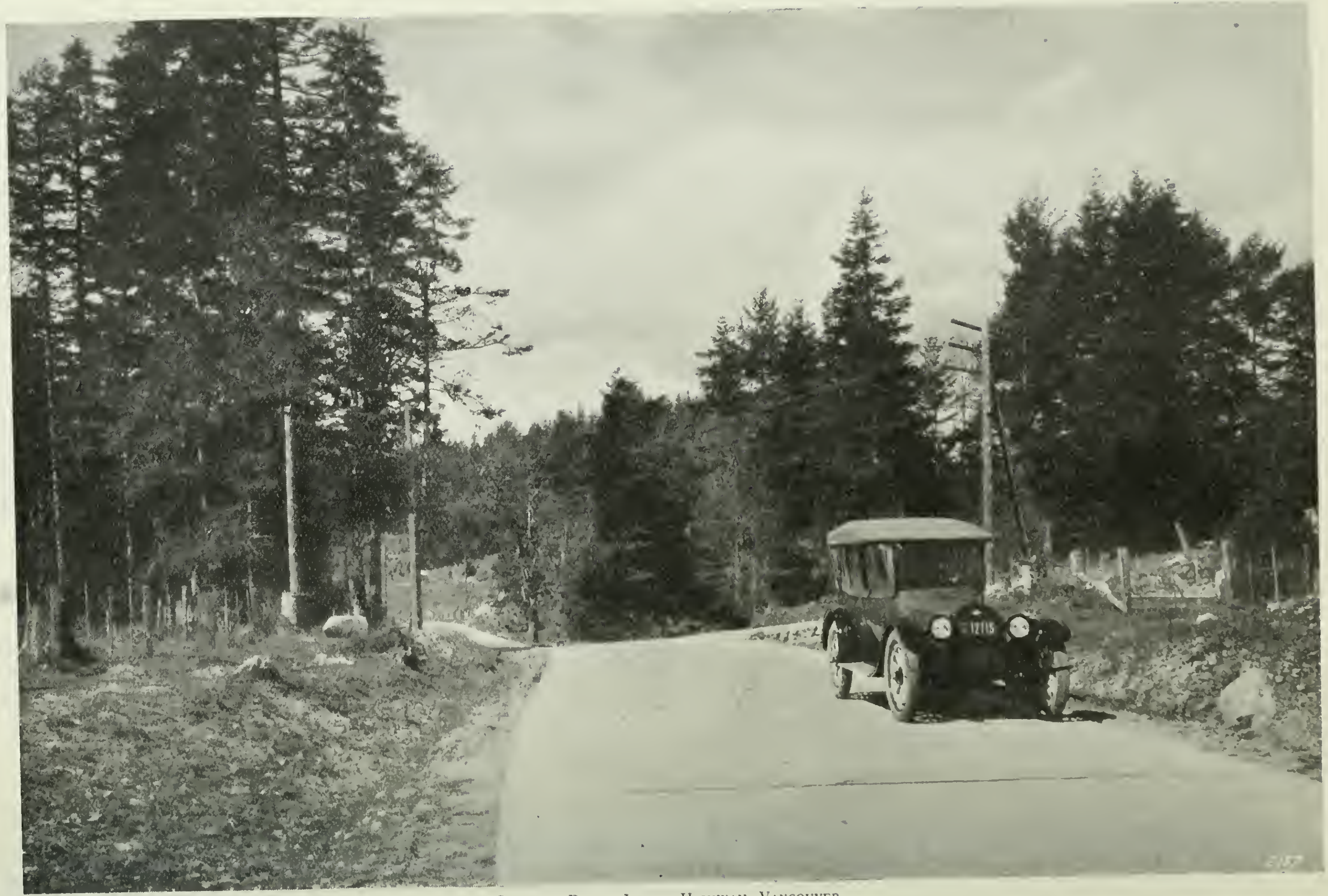


Colwood Road, Island Highway, Vancouver.
A Concrete Road laid in 1920.

REINFORCED CONCRETE ROADS.

By D. EDWARDS, A.M.Inst.C.E., F.S.I.
City Engineer, Bath.

Much has been done in an experimental form in the utilisation of reinforced concrete as a road material, but some hesitation still exists in the opinion of some as to its success as a road surface. For foundation work there cannot be any doubt upon its utility and economy, inasmuch as the reinforcement provides the necessary strength with a minimum thickness of concrete. Its use as a foundation for other forms of paving such as asphalte and wood, is now general, but comparatively few have yet made use of it as a road surface.

It cannot be denied that of a number of roads constructed with a concrete surface there have been failures, and the writer ventures the opinion that there have been good reasons to believe that the fault lies in the non-observance of the conditions which should govern the construction of a successful concrete road.

In the first place, too much attention cannot be given to the admixture of the concrete, the quality of the aggregate, and the proportional parts, without which success cannot be attained. The " wet concrete man " as a road maker in this direction will not be successful, as a suitable surface is only attained by the manufacture of a particularly dry concrete. The quantity of water to be used should not exceed 10¼ gallons to the cube yard when the aggregate is dry : should the weather conditions be wet, resulting in the sand and aggregate being wet, the quantity of water should be correspondingly reduced, so that the concrete when mixed will contain the same proportion of water.

It is impracticable to mix dry concrete, as is required, by hand labour and it is therefore necessary to engage a mechanical mixing machine for the purpose.

A Ransome mixer, capable of delivering one-fifth of a cu. yd. batch in five minutes, driven by a small 6 h.p. petrol engine, only consumes one gallon of petrol during 8 hours.

The semi-dry concrete thoroughly laid prevents the joining mark at the end of the day's work, and it may be mentioned that of the whole area laid by the writer it is not possible to direct attention to any joint excepting in two or three places, and there, even, the distinction is practically unnoticeable, the whole surface being uniform and well contoured.

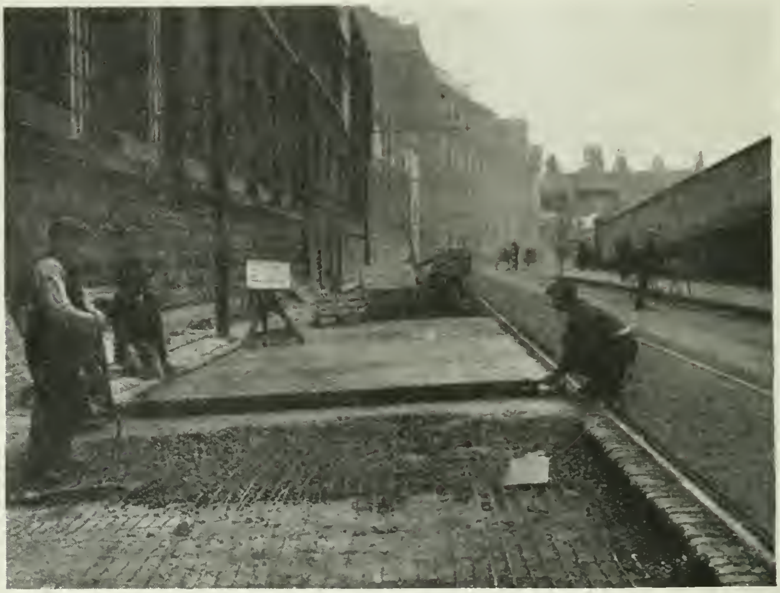
To illustrate the degree of dryness to which the concrete should be mixed, it may be mentioned that at the commencement of the work the men engaged in the laying complained that they were unable to obtain a " surface." However, the solution was obtained by a little more exercise of labour and skilled handling of the template.

In the construction of a concrete surface road the one thing to be avoided is the easily-obtained surface.

There is hardly need to explain that a semi-dry concrete maintains a homogeneous mass, retaining the large aggregate in the right proportion on the surface and equally distributed.

One has heard of concrete roads showing signs of wear within a week or two of being laid, the reason for which no doubt is, that the concrete contained an excess of water, so that the larger aggregate settled at the bottom, and the finer sand and cement brought to the surface to withstand the traffic.

The writer has laid several lengths of reinforced concrete roads, and from observations during the past six months, no one could doubt the success of this material in roadmaking.



Road in course of Construction, showing B.R.C. Reinforcement.

Completed Road. Lower Bristol Road, Bath.

The Lower Bristol Road (first class), which carries a very heavy and fast traffic, previously paved with granite setts, as well as a portion of the first class London, Bath and Bristol Road, are good testing grounds for the suitability of concrete as a road surface.

It would be conservative to say that concrete, however successfully laid, is the best material as a road surface, but it is in the writer's opinion the best material under certain conditions.

There are certain lengths of roads which are peculiarly suited to concrete, such roads being those which are (1) low-lying and waterlogged (and incapable of being drained except at an expense which is prohibitive) ; (2) roads which are narrow and overshadowed by tall buildings, etc. ; (3) those lying east and west, without sunshine and which remain damp and moist for the greater part of the year. Concrete is ideal in such situated roads, and, without doubt, it is a road surface which is best suited where it is impossible to avoid "rutting."

In connection with this it may be mentioned that the writer was at one time connected with the laying of a road in asphalte by a firm of repute under a guarantee for five years. In less than three months it was worn 1½ in. down for a width of 6 inches parallel with the tramway rail. The facts are as follows :—A tram track (3 ft. 6 in. gauge) situated in a narrow road with sufficient width on one side for a vehicle to pass. The intelligence of the horse, with his 2-ton wagon load on 1¾ in. tyres, found for him the line of least resistance by running one wheel of his lorry on the tram rail, and the other on the asphalte road, with the result that soon the full thickness was penetrated and for the whole length. The tractive effort on a concrete surface is considerably less than on asphalte or tarred macadam, particularly during hot weather, and consequently the traffic is more uniformly distributed.

The writer has completed an area of 5,800 sup. yds. of reinforced concrete on first-class roads, and he has no doubt that time will dispel the hesitancy which now exists as to the utility of concrete for road making.

The accompanying photographs show the work during construction and finished. The concrete was composed as follows :—3 parts good quality limestone, 1½ in. to ¼-in. gauge, 1 part ¼-in. gauge similar limestone, 1 part Bideford sand to 1 part cement, with 10¼ gallons of water (maximum) to the cu. yd., mixed by machine, and the fabric used was B.R.C. Ref. No. 9.

The cost of the work was 20*s*. 6*d*. per sup. yd. 6 in. thick inclusive of fabric, and the cost of clearing and preparing the site 3*s*. 9*d*. per sup. yard.

It is essential that four weeks shall elapse after laying, before the surface is subjected to traffic, during which time the whole surface is covered with a thick layer of sand or screened old road metalling, which should be thoroughly watered daily.

The advantages of reinforced concrete both from an economical point of view and efficiency, are quite apparent, particularly so in foundation work for other forms of surfaces such as asphalte and wood.

By the introduction of a suitable fabric the thickness of the concrete may be considerably reduced and the necessary strength maintained.

Concrete at a cost of 32*s*. a super. yard 12 in. thick may be reduced to 8 inches, thus a saving of 10*s*. 8*d*. per yd. sup. is effected : from this is deducted the cost of the fabric at say 3*s*. 3*d*., which gives a net saving of 7*s*. 5*d*. per sup. yard.

There is also to be considered the reduction in the cost of the 4 in. extra foundation, also the more expeditious performance of the work, and a lesser inconvenience to the general public and road users.

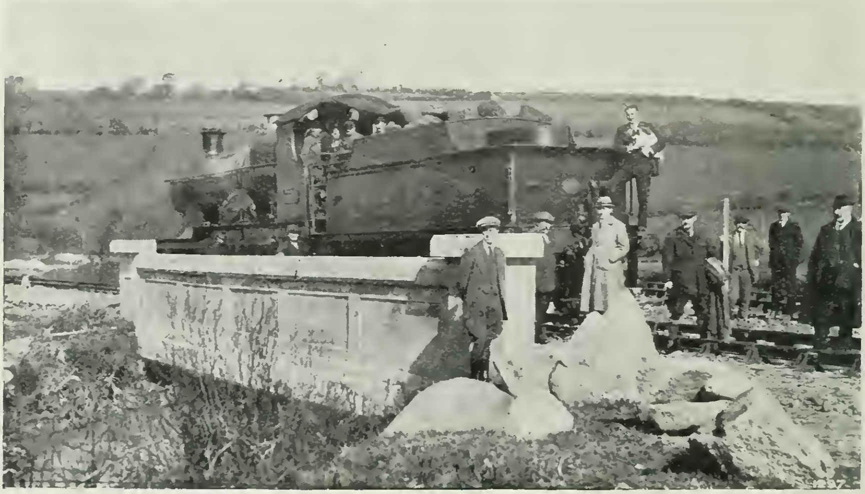
A reinforced concrete road undoubtedly makes a good road surface, admirably suited for difficult situations and heavy traffic, and whilst its extended use on all forms of roads may appear to be somewhat retarded, the time is not far distant before more attention will be paid to road construction of this kind.

Par River Bridge.

PAR RIVER BRIDGE.

The following rather interesting particulars of a bridge under test appeared in a recent issue of the "Indented Bar Bulletin" to whom we are also indebted for our illustrations.—Ed.

The bridge spans the Par River at an angle of 55° to the bank, and has an overall average length of 53 ft., the width over the parapets being 18 ft. 6 in. It is supported at each end on mass concrete abutments 31 ft. long, 4 ft. thick at the base, tapering to 3 ft. at the top. These abutments are 8 ft. 6 in. in height, and are sunk to a depth of approximately 5 ft. below the water level, supported on ten reinforced concrete piles, three set at either end of each abutment, and the other four being placed in pairs, so as to support the abutment immediately beneath the rail beams. These piles are 12 in. square in section, project 12 in.

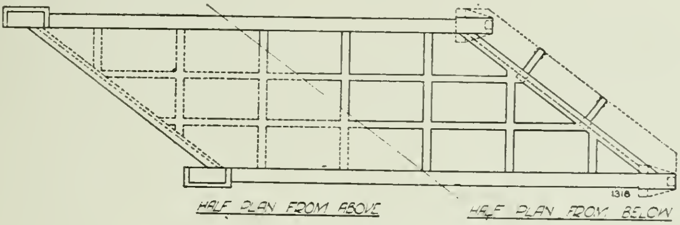


Par River Bridge under Test.

into the abutments, and extend 15 ft. on one side and 30 ft. on the other, below them. The parapet walls act as the main beams supporting the bridge, the clear span being approximately 46 ft. They are 6 ft. 6 in. in height, and 12 in. thick, panelled on the outer faces. A coping is formed on the top of these parapet walls 18 in. by 12 in. in section, which also acts as the top boom of the beam.

Panels are recessed 3 in., and the wall is thickened at the lower level a further 3 in., which considerably adds to its architectural appearance, as can be judged by reference to our illustration.

The decking is composed of a 4 in. reinforced concrete slab, carried by beams at each end of the bridge 18 in. by 12 in. in section, resting on the abutments, and intermediate beams 24 in. by 10 in. in section spaced approximately 9 ft. apart, formed at right angles to the parapet walls. As will be seen by reference to the diagram, three of these extend right across the bridge, the two at either end, owing to the fact that the bridge is built on the skew, span between the parapet walls and the beams supporting the end of the decking slab. Two rail beams were formed to carry the track, and these extend the length of the bridge, being supported by the beams previously mentioned.



DETAILS OF SUPPORTS—PAR RIVER BRIDGE.

At either end of the parapet walls pillars 8 ft. high, 4ft. wide, and 1 ft. 9 in. thick, were formed, surmounted by caps measuring in plan 5 ft. by 2 ft. 3 in. and 1 ft. 3 in. thick.

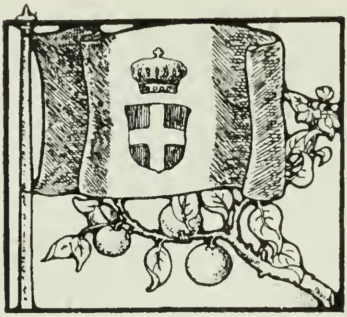
The bridge was designed to carry a distributive load of 106 tons, and when it was tested by an engine and tender weighing approximately 88 tons, the deflection measured only $\frac{1}{16}$ in.

The bridge is of particular interest, since it is believed to be the first underbridge on the Great Western Railway to be constructed of reinforced concrete.

Messrs. Cowell & Drewitt, of Newquay, were the architects, and the work was carried out by Mr. Gower B. R. Pimm, of Exmouth. The reinforcement throughout consisted of indented bars, and the Indented Bar & Concrete Engineering Co., Ltd., were responsible for the design of the reinforcement.

MEMORANDUM.

Jointing Concrete Structures.—The *Engineer* states that a system of making watertight the joints in concrete structures, such as dams, has been devised by Mr. F. B. Smith of San Francisco. During the process of construction a groove is formed at the joint and is filled with asphalt blocks. The blocks have a hole down the centre through which a pipe is threaded and left in place. Two such sets of blocks are arranged close to one another, and the bottom ends of the pipes are connected together. When the structure is finished the asphalt is melted by passing steam through the pipes. If settlement subsequently takes place the asphalt can be re-melted and added to if necessary.



REINFORCED CONCRETE IN ITALY.

(Contributed.)

Most Englishmen who are tempted to study or visit Italy are usually drawn by the artistic and historical interests which centre round that country of almost constant sunshine.

For some it is the Italy of the Romans that they want to see and study; for years at school they were forced to wallow in the sayings and doings of the Romans, and although they objected most strongly to Latin—as in fact they objected to most things requiring mental effort—they retain an interest in the stage upon which the drama of Roman civilisation was acted.

Others are attracted by the fact that Italy has been the cradle of art, and still is the natural home of the artist; it is a land of long sunshine, wonderful wine and plentiful simple food, a land where few things matter and where one can live in that borderland of indolence which seems essential for the artistic temperament.

All the books that we have read upon Italy have been written by people whose interests have been pre-eminently either artistic, historical or religious, and therefore we have little opportunity of forming a mental picture of the country as it will appear to the engineer.

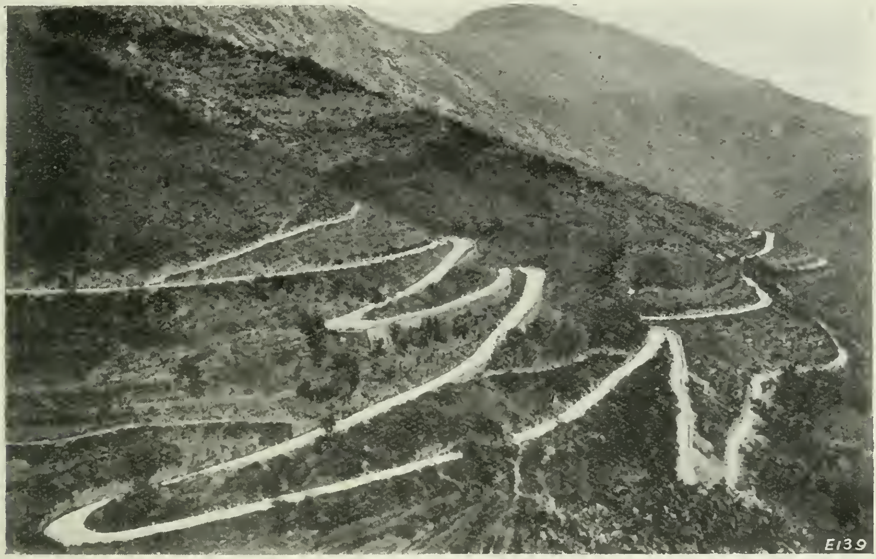
The fact is that Italy is to us a land of contradictions; the people are industrious yet lazy; they are progressive though conservative; they are always washing clothes, but their towns are filthy. Within sight of each other one may see a donkey drawing water from a well in a manner that reminds us of pictures in the illustrated Bibles that we saw in our youth, and a reinforced concrete factory under erection.

These contradictions have succeeded in giving most English people a false impression of the Italians, especially as most of the writers on Italy are people of literary or artistic interests who have little sympathy with, and less understanding of, engineering matters.

In a journey from the French-Italian border to Genoa by train one can see more reinforced concrete work than in a train journey in England; in making this statement it is borne in mind that there is more time for studying the scenery on an Italian railway journey than in England. The trains stop at practically all the stations, and the low platforms make getting in and out of the carriages a matter of difficulty that involves longer waits.

Starting from Mentone, which, though in France, is within a mile of the Italian border and is essentially more Italian than French in character, the writer was first struck by the fact that on a walk into the country he found that the many bridges spanning the rivers and streams—then dry—were in reinforced concrete.

Some quite interesting work is to be seen on the tramway that runs to Sospel. This runs for about twelve miles, the first seven of which zig-zag up the mountains ; the line passes through a tunnel just before reaching the summit of the road at the village of Castillon (it is interesting to note that in the old maps this village is called by its Italian equivalent Castiglione, a name of interest to structural engineers). The nature of the country can be gathered from the photograph, which shows clearly the road with the tramway track at the lower right hand corner just before the line enters the tunnel. A reinforced concrete viaduct has been constructed projecting right out on the side of the mountain, in order to enable the tramway to ease the " hair-pin " bend provided on the road.



THE SOSPEL ROUTE.

From Mentone to Genoa several interesting examples of reinforced concrete work were seen in progress at the small sea-faring towns on the coast of the Mediterranean. At Savona, a town of considerable manufacturing activity, some one-story reinforced concrete workshops were in course of erection quite close to the railway, and from the casual inspection which the writer was able to give from the carriage window, the form-work did not appear to be constructed with great care.

Small concrete structures are to be seen everywhere ; elevated concrete water tanks are provided at nearly every railway station, and they look very well.

Concrete fencing also is to be seen everywhere ; in this country we see a good deal of wire fencing with concrete posts, but the form of fencing seen in many places in Italy consists of reinforced open-work concrete grids formed in pre-cast lengths of about 6 ft.

At one place the writer noticed lying upon the ground the mould in which some of these fencing units had clearly been cast. These units are erected between posts, and the effect of the complete fencing is quite pleasing. In addition to this kind of fencing a large number of concrete walls were to be seen ; these had been left for the most part with the form-work boards showing clearly on the surface.

All along the coast of the Mediterranean there are rivers and streams opening into the sea. For many months during the year the beds of many of these rivers are quite dry, and in others a small stream trickles down the centre, and on fine days in the towns women may be seen kneeling on the stones at the sides washing clothes in water, the clothes being laid on the dry stones in the sun for drying. These river beds provide splendid material for concrete. After heavy rains and a melting of the mountain snow these rivers become raging torrents, and boulders of rock are tumbled seawards. In this tumbling process the rock becomes pulverised and cleaned, and during the periods that the river beds are for the most part dry excellent concrete-making material may be lifted therefrom ; in many places one can see carts on the dry river beds being filled with the well-graded material.

In several places there were buildings to be seen—apparently for hotels of moderate size—in course of erection with walls formed with a kind of rock rubble and the floors and roof in reinforced concrete, the floors being continued through the window openings to form cantilevered balconies.

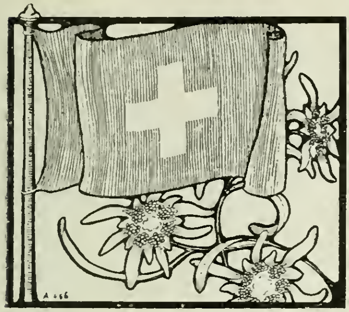
In Turin and Milan—towns of great manufacturing activity—there are to be seen a large number of reinforced concrete factories and office buildings, and practically all the new work in course of erection appeared to be in reinforced concrete.

It is quite surprising to a British engineer to find such progress in reinforced concrete in a country in which the people are essentially conservative in outlook, and in which many of the customs belong almost to the middle ages ; the Italian postal service, for instance, is almost a joke. A friend in Rome, to whom I wrote announcing a visit next day, smiled when I expected that he had received my letter ; it takes three days to deliver a letter from one part of the town to the other, and nobody thinks of using the post.

It is remarkable that we find people in this country still opposed to concrete ; we still come across some architects or town surveyors who tell us in dare-devil fashion that they are experimenting with concrete buildings as if they were embarking upon some perilous adventure to the Spanish Main. It is a mistake to speak of concrete construction as new ; concrete is not new but old ; it is as old as the hills—in fact it is part of the hills.

MEMORANDUM.

Pumice Stone and Salt.—Among materials for building and construction Koka Seki, a variety of pumice stone found in the Niijima Islands off the coast of the Idzu Peninsula, has some reputation in Japan. It is claimed that this material, on account of its durability, high tensile strength, and capability of resisting 1,300 deg. C. of heat, is suitable for boiler and furnace construction and for the inner linings of safes and ice-chests. It is used in Japan in the building of barges of reinforced concrete. This concrete is said to be 60 per cent. lighter than the ordinary kind and to be proof against water erosion, or serious breakage by freezing and thawing.



REINFORCED CONCRETE WORK IN SWITZERLAND.

The following information has been abstracted from a series of articles which appeared in the "Schweizerische Bauzeitung," and we are indebted to that journal for permission to reproduce the illustrations shown.—Ed.

THE GÖSGEN WATER-POWER STATION ON THE AARE.

An extensive water-power station has been completed for the Olten-Aarburg Electric Supply Company, in which the waters of the well-known river Aare are now utilized, thus adding one more to the number of Swiss works which are driven exclusively by water-power. By cutting through a bend in the river near the village of Gösgen the equivalent of 3,000 h.p. has been made available and by constructing a dam a further 13,500 h.p. is secured. These figures are in addition to the power produced by the main stream, and the total h.p. available and for which the turbines are provided is 45,000 h.p., which is derived from a flow of over 410 cub. yds. per second.

The works occupied just over four years in construction, the retaining dyke being commenced in the autumn of 1913, the canal in 1914, and the machine house in 1915. The first use of the water for power-production was on the 27th of November, 1917. Since then the works have been thoroughly proved and are entirely satisfactory.

Contrary to custom, the level of the water is regulated by its flow over controlled weirs, and not through outlets near the base of the dam-wall. This arrangement was considered

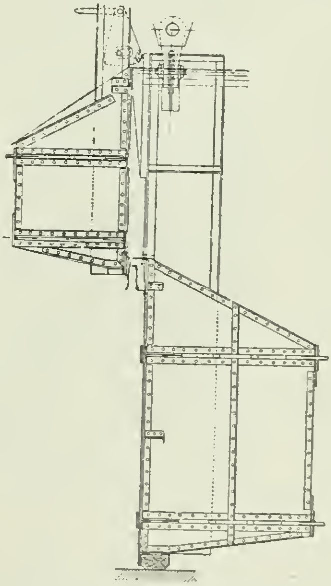


Fig. 1. Construction of the Weir.

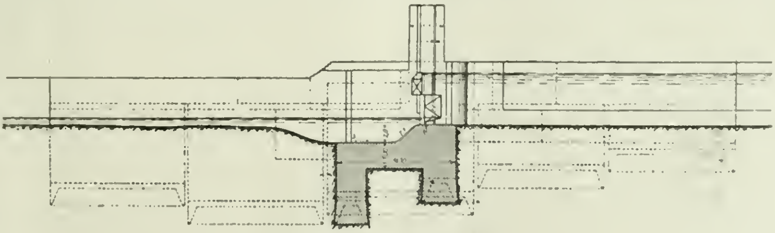


Fig. 2. Cross Section of Weir.

The Gösgen Water-Power Station on the Aare.

to be less straining during times of storm, such as are prevalent in the district. The wall has a total length of 100 yds. between the wing walls and it is provided with five openings, each 52 ft. wide. The pillars and cills are fixed by means of caissons. The chief cill has a double profile, with an upper and lower caisson and deep foundations between ; this arrangement being used to prevent leakage under the great pressures involved. Most of the cills are 2 ft. below low water level, but a still lower one is built at the side for use when required. The general construction is shown in *Figs.* 1 and 2. The caissons nearest to the bank are of reinforced concrete, but the others are of iron

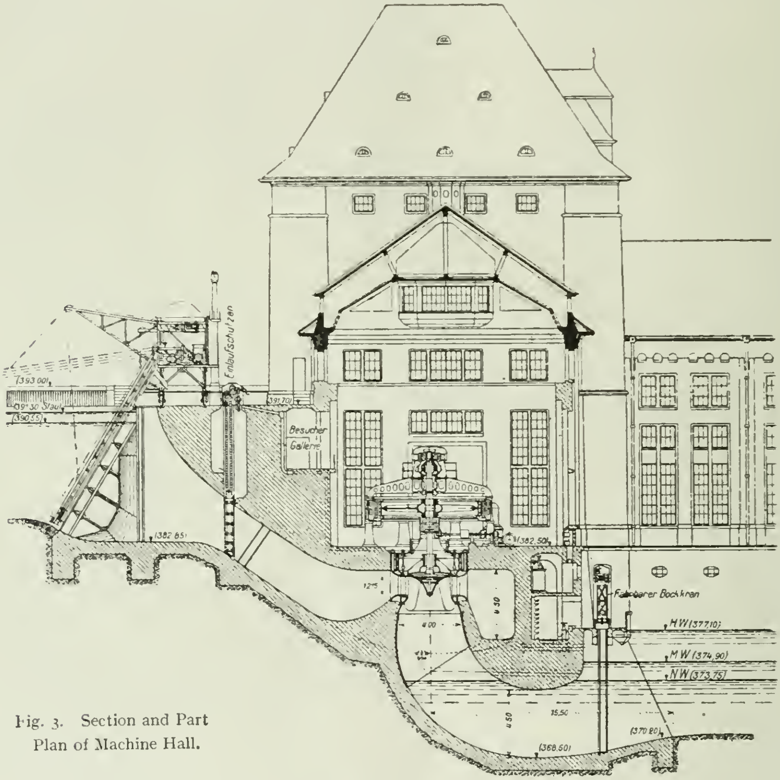


Fig. 3. Section and Part Plan of Machine Hall.

The Gösgen Water-Power Station on the Aare.

The pillars and cills are of reinforced concrete with limestone and granite facings.

The following procedure was adopted wherever possible :—The pillars were first constructed, placed in position and the upper and lower caissons were then sunk and on them a temporary retaining wall was erected so as to enable the intervening work to be constructed and sound joints ensured. In some places the bed of the river was of so sandy a nature that the water rose through it and a temporary caisson was then used. In this way the constructional work was not only strengthened at each side but also in a downwards direction, so that by the time the granite or limestone masonry was to be fixed an entirely dry base was secured.

In order to make better joints than is customary in structures of this kind, trapezoidal extensions were constructed and these were then cut out and concreted by means of a portable caisson, thus producing an entirely solid joint which was properly attached both to the pillars and the walls.

Special efforts were made by the designers to ensure not only the best possible flow of water to and from the turbines, but also to reduce the building costs as far as was compatible with stability and efficiency. For this reason they sought to remove as little as possible of the natural rock forming the foundation. To this end, ribs were formed in the rock and wherever excavations were needed they were lined with a 28 in. mass of concrete.

The foundations of the machinery hall, the various load-carrying structures such as the crane beams, the supports of the tower and the roofs were all executed in reinforced concrete. The whole building from foundation to roof is divided into three independent sections by two expansion joints. To prevent seepage these joints are zig-zagged.

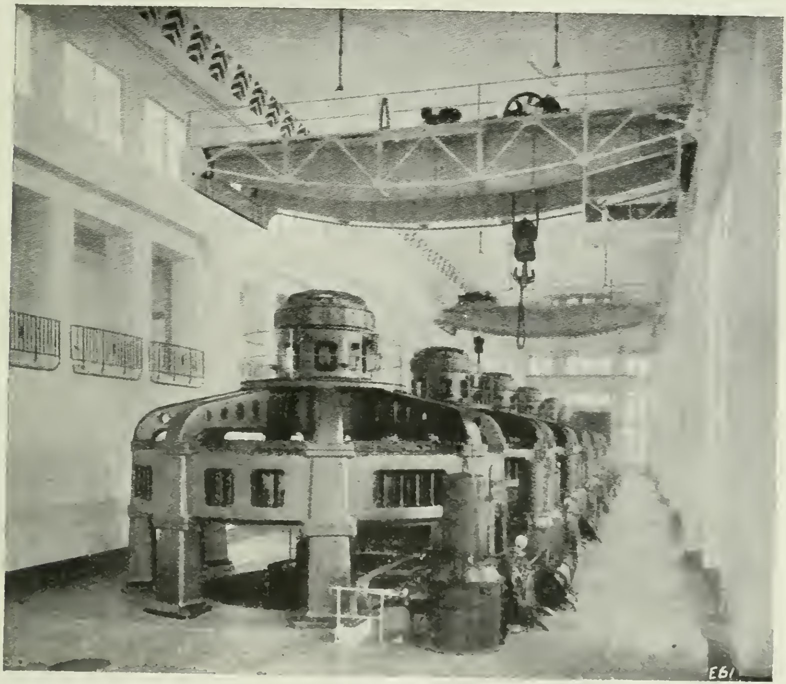


Fig. 4. Interior of Machine Hall.
THE GÖSGEN WATER-POWER STATION ON THE AARE.

The foundation work below the spiral inlet is only slightly reinforced, but the spiral and the walls of the Machine Hall are completely reinforced. The suction-pipe or inlet was also made of reinforced concrete, its construction being shown in *Figs.* 5 and 6.

The floor of the Machine Hall is anchored to the foundations by means of the reinforcement of the outer wall of the spiral and anchoring irons. Horizontal forces are also provided for in the reinforcement, this being specially necessary because of the expansion joints previously mentioned. The floor of the Machine Hall was also supported during erection on massive concrete pillars above the spirals, but these pillars were afterwards cut through and removed.

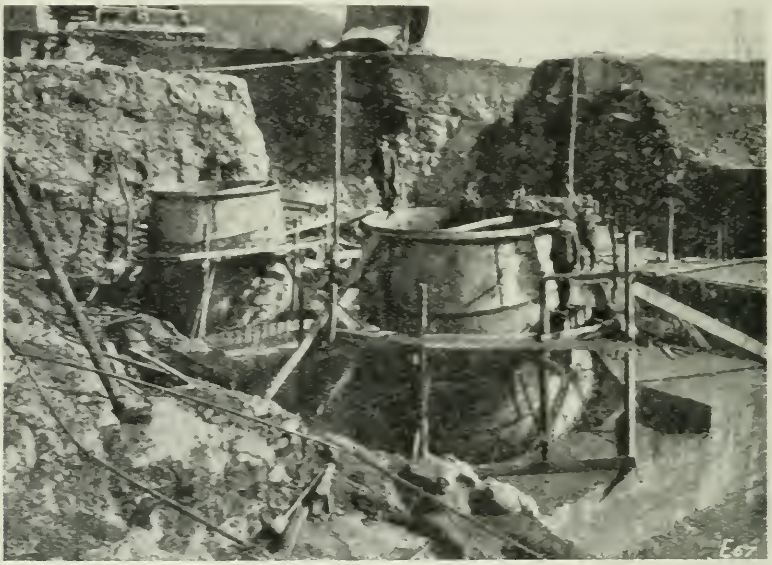


Fig. 5. Upper End of Inlet.

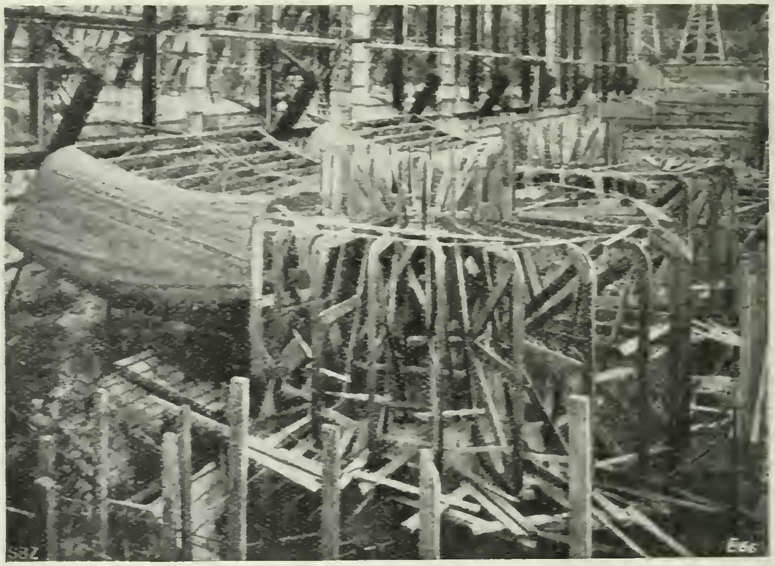


Fig. 6. Reinforcement of Spiral.

THE GÖSGEN WATER-POWER STATION ON THE AARE.

The concrete used for the inlet was waterproofed, but for further safety a good drainage system for seepage was provided.

The superstructure of the Machine Hall is of reinforced concrete partially faced with cement ashlar. It is particularly noteworthy that the crane beams (*Figs.* 4 and 9) are of reinforced concrete. The roof trusses are in the form of frames with tension bands and links to the eaves. The purlins, which have to

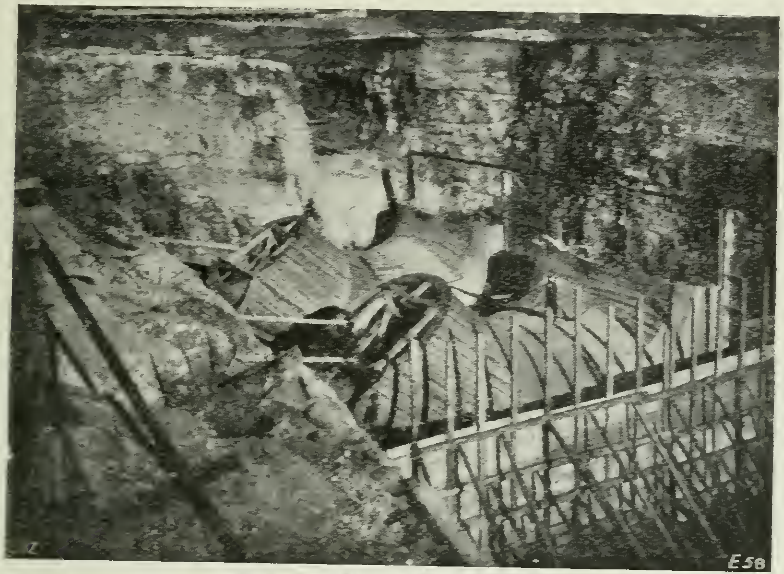


Fig. 7. Shuttering of Inlet Sluices.

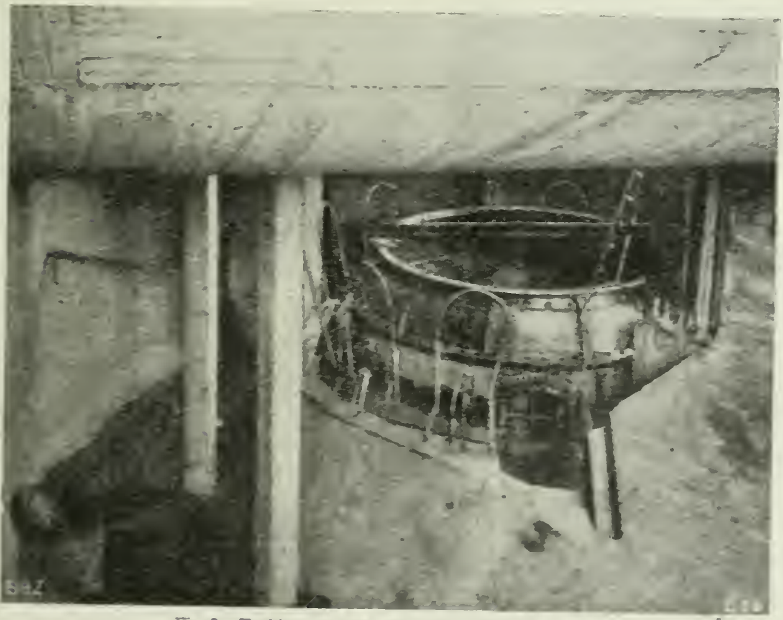


Fig. 8. Turbine Chambers, showing Temporary Puters.

THE GÖSGEN WATER-POWER STATION ON THE AARE.

carry the weight of the roof over a span of 40 ft., are made in compartments. The roof itself is of hollow tiles on concrete rafters.

The arrangements used for handling the raw materials forming the concrete were designed so as to require a minimum of labour. The cement and aggregate were assembled at one side of the river, the aggregate being in two separate lots, so that it could be washed and graded in suitable appliances. The raw material was elevated, tipped into a grading machine, the coarse aggregate passing to a silo prior to its being washed and then sent to the storage silos. The sand was also washed and collected in a wash-back, from which it was loaded into trucks and taken to the silos. In order to ensure effective washing the water was supplied at a pressure of 100 lb. per sq. in. The grading and washing plant had a capacity of 400 cub. yds. per day. The silos had a capacity of 800 cub. yds. of graded material.

From the silos the material fell into trucks, in which it was taken to one of two concrete mixers of 270 cub. yds. and 135 cub. yds. daily output respectively. The proportions of sand, gravel, cement and water were measured automatically to the mixers. It was found that the output of the mixers was largely independent of the grading and washing plant, but was greatly influenced by the amount of concrete placed. The latter averaged 160 cub. yds. per day, but on one occasion rose to 215 cub. yds. per day.

Cranes suspended from three overhead ropeways conveyed the materials to the workmen, each of the ropeways being mounted on two portable towers running on rails. Two of the ropeways had towers 43 ft. high, a span of 1,290 ft., and a load-carrying capacity of 3 tons at a speed of 3 ft. per second and an output of 130 cub. yds. per day of 10 hours. The third ropeway had towers 60 ft. high and a carrying capacity of 2 tons; it was used chiefly for the highest part of the work. The concrete was carried in skips of ¾ cub. yd. capacity with hinged bottom.

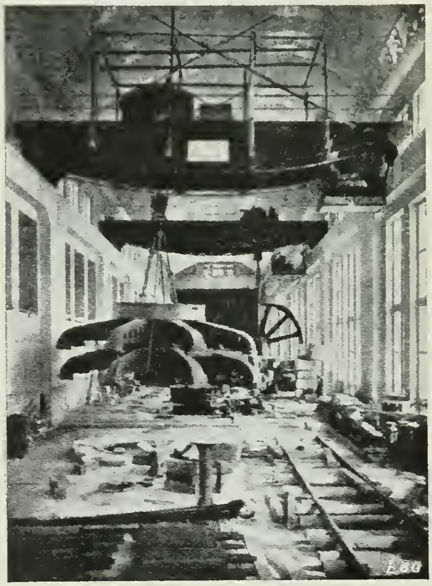


Fig. 9. Interior of Machine Hall—Testing the Crane.
THE GÖSGEN WATER-POWER STATION ON THE AARE.

The total amount of concrete used for the Machine Hall and accessory buildings was 48,000 cub. yds., and to reinforce this 731 tons of iron were used, of which 547 tons were employed on the foundations of the Machine Hall

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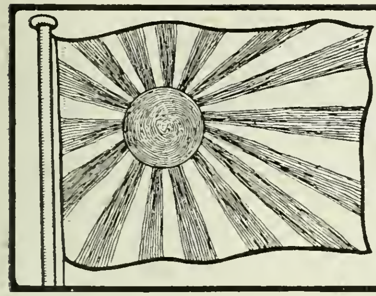
Concrete Road Development in Canada.—At a recent gathering of the Canadian Good Roads Association, Mr. H. T. Van Scoyoc indicated that the present tendency in concrete road building in Canada is to build wider roads than heretofore; it makes the stresses much less, especially under Canadian climatic conditions; further, heavier reinforcement is being specified. Some of the specifications also prevent the placing of the materials on the road itself, that is, the material must be brought to the machine without being placed on the subgrade. The longitudinal centre joint is also finding much favour.



CONCRETE WIRELESS TOWER 672 FT. HIGH IN JAPAN.

The following interesting particulars and illustrations are taken from "Engineering News Record."—Ed.

A reinforced-concrete tower 660 ft. above ground level and 672 ft. above the bottom of footings has been built as a wireless telegraph station at Tokyo for the Imperial Japanese Government. This is the highest masonry structure on record, surpassing by seventy or more feet the record-breaking chimney. A view herewith shows the structure completed to the 360-ft. level and the drawings give the important details of design.

The tower is coniform in shape and follows chimney practice. At ground level it has a shell thickness of 33 in. and a centre diameter of 55 ft. There is a straight taper to a shell thickness of 6 in. and a centre diameter of 4 ft. Reinforcement consists of vertical rods and hoops. At the base there are 200 1-in. vertical rods with ¾-in. round hoops on a 4½-in. pitch; at the 100-ft. level, where the reinforcement is heaviest, there are 285 1⅛-in. verticals and ⅝-in. hoops on a 5½-in. pitch; at the top there are 25 1-in. verticals with ⅜-in. hoops on a 7-in. pitch.

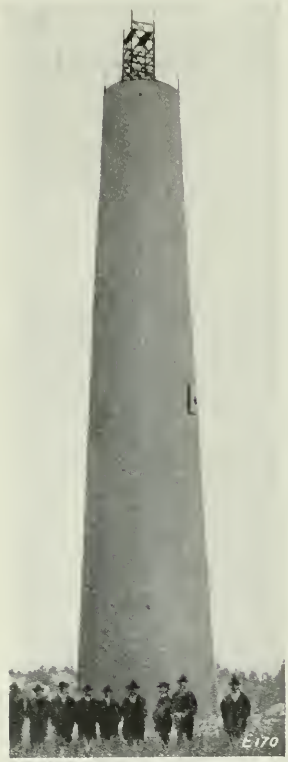
The base consists of an annular ring of triangular cross-section, 12 ft. high and 32 ft. 10 in. wide, leaving a central opening not covered with any footing. This base rests directly on a firm gravel and clay formation; it is heavily reinforced as shown in the accompanying drawing. As the base is about 50 ft. above the water, the top of the tower is approximately 720 ft. above sea level.

A wind pressure of 30 lb. per sq. ft. of projected area and temperature stresses due to a range from 20 to 100 deg. F. were factors in the design, which was checked by Professor Shibata of the Imperial University of Tokyo. Further, the tower is designed to withstand earthquakes, which are numerous in Japan. The pressure on the base is about 4,200 lb. per sq. ft., exclusive of wind load. Gravel concrete of 1 : 2 : 4 mix is used, made with Japanese portland cement and mixed to a fairly wet consistency. There are approximately 4,420 cu. yd. of concrete in the shaft and 1,640 cu. yd. in the foundation, together with 425 tons of American steel.

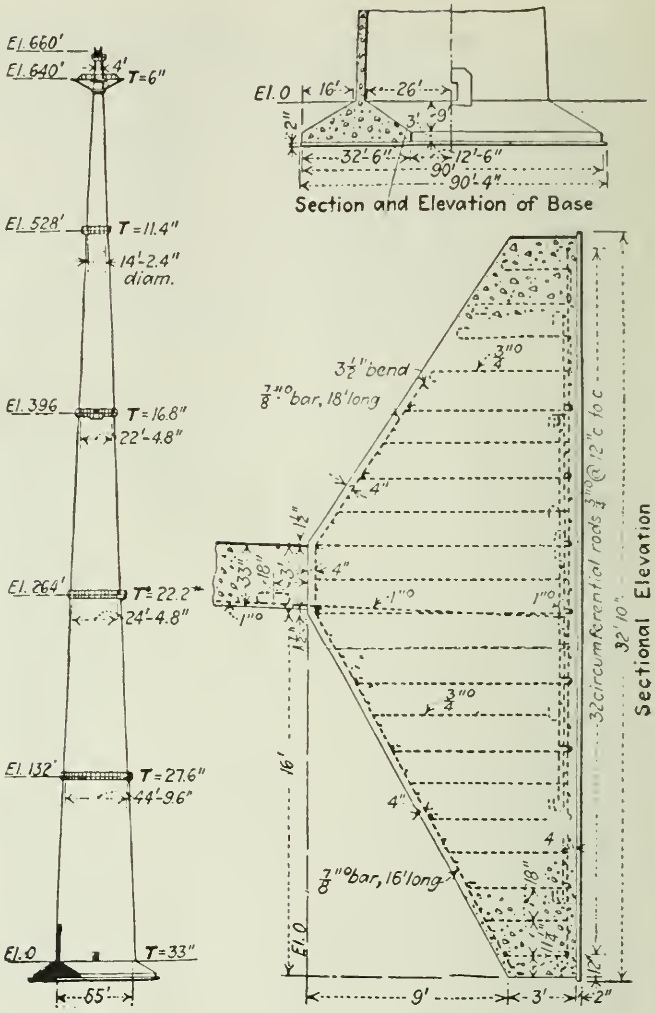
All construction work and hoisting of material was done from a central timber tower. Three 5-ft. lifts of wood forms were used, each lift being bound with wire cables. As soon as the top or third form was filled the first form was released and erected on top. Progress ranged from 88 cu. yd. per day at the bottom to 1·2 cu. yd. per day near the top. All the work was done by native labour.

In the centre of the shaft is a steel stairway leading to an open platform at the top and having landings to exterior galleries at intervals. At the top are steel arms for the inclined wire antennæ, which are led to the ground. It is expected that the plant will give direct wireless communication with San Francisco, Cal.

The tower was designed and erected according to the patented system of the Weber Chimney Co., Chicago, the work being executed under the supervision of the Oriental Compressol Co., Tokyo, Japan.



672-FT. CONCRETE WIRELESS TOWER AT THE 360-FT. STAGE.



DETAILS OF BASE AND GENERAL DIMENSIONS OF HIGH CONCRETE TOWER IN JAPAN.

MEMORANDA.

The Cost of Concrete Roads.—It is interesting to note that estimates received for relaying about a mile of the main thoroughfare through Trowbridge showed the following figures :—To lay the road in reinforced concrete was to cost £19,000, whilst the use of concrete foundation with wood block surfacing would have cost £26,000.

Southsea.—Very interesting examples of reinforced concrete road work are at present being constructed at Southsea. The Esplanade, approximately 2,700 ft. long by 18 ft. wide, is being laid with concrete 6 in. thick, reinforced with B.R.C. Fabric No. 9. The carriageway, approximately 3,940 ft. long by 40 ft. wide, is also being constructed in a similar manner. Of the Esplanade 2,300 ft. and of the carriageway 2,000 ft. have been completed up to date. The work is being carried out by direct labour for Mr. A. W. Ward, Borough Surveyor, Portsmouth.

CONCRETE IN THEORY AND PRACTICE.

A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.

REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—Ed.

81. Steel for reinforced concrete is by preference *round* in section. Other sections are on the market and it is well to consider why the round is the best.

The makers of some bars claim that with a bar having much greater surface area for a given cross-sectional area, as for example with a flat, angle, T, or a cruciform and similar sections, the adhesion between the steel and concrete will be improved. Tests show that in general this is not the case. Though the adhesion is commonly expressed in so many pounds per square inch of surface, the adhesion per square inch is far less for these flat sections than for a round bar. The reason for this is that adhesion is really a measure of the friction between the steel and the concrete, the pressure between the two being produced by shrinkage of concrete round the steel. Now any section except a round bar will necessarily have corners, and when shrinkage of the concrete occurs, there is a great tendency for it to start splitting cracks from these corners, relieving it from the tension which produces the pressure between concrete and steel on which the adhesion depends.

Another objection to all bars deviating from the circular section is the danger of forming pockets of air and water under the bars, and in the angles, when the concrete is placed. This danger is greatest with sections having re-entrant angles (like a cruciform section, T, or angle), but is quite important even with a flat, or square.

82. Bars are on the market designed to improve the adhesion between concrete and steel by the provision of projections at short intervals. When embedded in large masses of concrete, the adhesion is undoubtedly improved, but with the small amount of cover which is given in practice, the splitting tendency of such bars is very marked and their effectiveness doubtful.

In any case, it is only in exceptional circumstances that the adhesion stress between concrete and steel exceeds what is readily given by the use of plain round bars, as is evidenced by the fact that probably nine-tenths of the successful reinforced concrete structures have been constructed with plain round bars.

It must also be remembered that any bar other than a commercial section, costs more and restricts one's market.

83. Where the adhesion stresses are great, *hooks* at the ends of bars are often very desirable. These may take the form of a right-angle bend or a ⊂ hook.

The former (*a*) should have a length of about four times the diameter of the bar. Little is gained by making it longer, as the hook bends under load, and only the portion nearest the bend bears against the concrete.

A ⊂ hook (*b*) should have an internal diameter of not less than four diameters of rod, and a total length of about eight diameters at least.

Hooks fail by putting a great eccentricity of tension on the bar, the resultant pressure on the concrete being well outside the bar.

Fishtails are free from this defect. These are best made by sawing the bar down a distance of three diameters from the end, and then splitting the ends out. This form is rather costly. [*Fig.* (*c*) and (*d*).] Another form is made by shearing the rod between two shears at

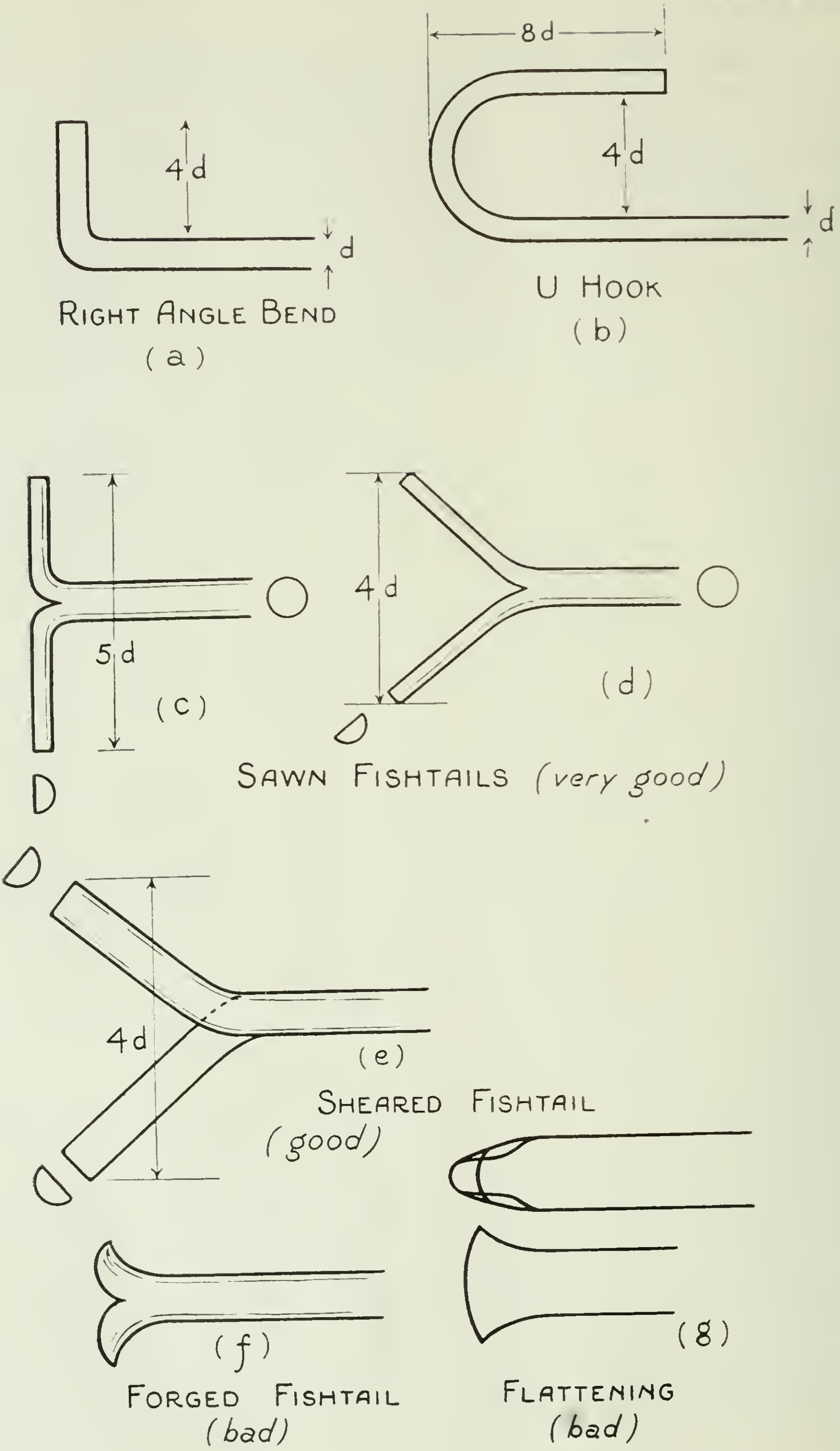


Fig 12. Showing Different Forms of Hooks for Reinforcing Bars.

45° to the axis of the rod. This is a very cheap form, though not so good as (*d*) because it exposes a cutting edge instead of a rounded surface to the concrete and only half the projected area. Merely flattening the end down is not good, the area of bearing against the concrete being too small. [See *Figs.* (*f*) and (*g*).]

84. The most usual *quality of steel* is commercial mild, which has a breaking strength of 28 to 32 tons per square inch, and a yield point of about 20 tons per square inch.

Many firms and individuals have advocated the use of a harder steel, with a higher elastic limit and strength, on the ground that with a stronger steel it is permissible to use higher working stresses. This increased strength may be obtained in one of two ways, either by altering the chemical composition of the steel, or by mechanical treatment.

The former, in practice, means increasing the carbon contents in the steel, and by this means the strength and elastic limit can be raised about 30 per cent.

The danger lies in the brittleness which may, and often does, result. The author knows of too many cases where steels of this class (technically known as "semi-hard" or "higher carbon") have broken off short in process of bending. How many bars were damaged in bending, without actually fracturing!

In the author's opinion, the increased strength which undoubtedly can be obtained in this way at little extra cost, is accompanied by some extra risk of brittleness and should be used with an increased factor of safety.

Another method of producing a stronger steel is by overstraining a bar of mild steel.

This is done, for example, in wire-drawing, and it is common to produce a ¼″ wire with a breaking strength of 40 tons per square inch and more from a steel having a strength of less than 30 tons per square inch. In the case of smaller wires, where the drawing has been greater, much higher strengths are often produced.

Similarly if a bar is twisted cold to a sufficient extent, its strength is increased. Sometimes bars of square or other angular sections are twisted, so as to produce this increased strength and an increased adhesion simultaneously.

The increased strength obtained mechanically as explained, is probably freer from risk of brittleness than high-carbon steel, but is open to the danger that it is lost if the bars are heated.

Now though small bars are generally bent cold, larger ones are often heated, and then this extra strength is lost. The writer knows of cases where this happened against the designer's intention, and where the increased strength on which he had figured was lost. In one such case, additional bars were added to make good, but had it not been noticed, the structure would have been weaker than intended.

Certainly where higher stresses are allowed than would be safe for mild steel, much greater care in testing and supervision is needed, and a greater factor of safety is desirable.

85. *Conclusion.*—In the foregoing, it has been attempted to explain in a general way in simple language the nature of the problems which confront the designer and constructor of reinforced concrete structures. What has been prominently kept in view has been the importance of combining accuracy with a simple statement. It is, of course, easy to simplify at the expense of accuracy, but not very helpful. Thus, it would be simpler to think loads on columns were concentric—only it is so very obvious that they are not, and if the author has succeeded in giving an accurate representation of the general problems, he believes the time may have been well spent.

He is, of course, well aware that no short and simple treatment can be *complete*. It is, in fact, only intended to serve the purpose of an introduction to the subject, leaving those who desire to specialize in the material, to follow this up with further study of the ordinary technical works, but without, the writer hopes, having to unlearn anything suggested in this short discourse.

CONCRETE AT THE BATH AND WEST AND SOUTHERN COUNTIES SHOW.

If any evidence were wanting in order to demonstrate the application of concrete in an ever widening degree to agricultural purposes, it was to be found in the exhibits of the *Teign Valley Granite Company, Ltd.*, of Trusham, Chudleigh, Devon, and the *Wharf Lane Concrete Co., Ltd.*, of Ilminster, Somerset, at the Show of the Bath and West and Southern Counties Society recently held at Bristol.

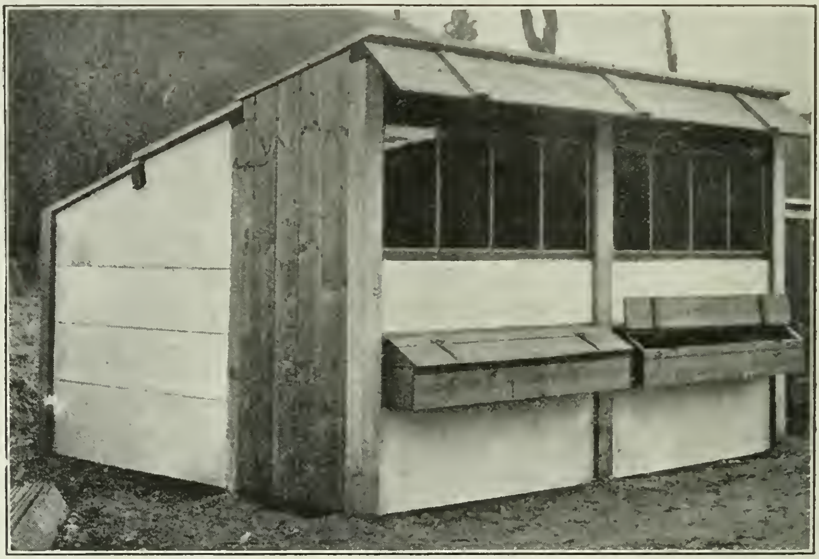


Fig. 1. A Concrete Poultry House.

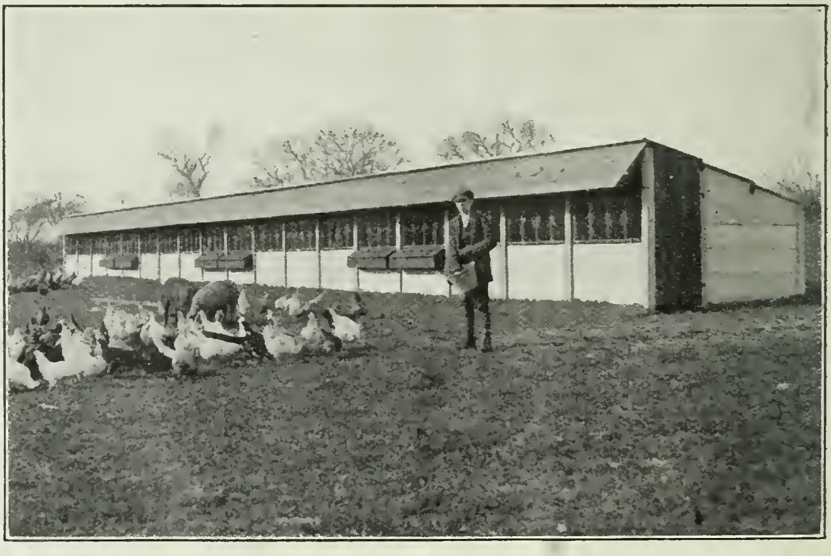


Fig. 2. A Range of Concrete Poultry Houses, 187 ft. long.

The speciality of the *Teign Valley Company* appears to be the utilisation of concrete for poultry houses and pigstyes, on the pier and slab principle, as shown in the illustrations herewith. *Fig.* 1 shows a single poultry house, and *Fig.* 2 the same method applied to a range of houses some 87 ft. long. Similarly, *Fig.* 3 is the photograph of a concrete pigsty, but these, again, can be erected in rows of any number with a proportionally reduced cost for each individual sty.

This application of concrete was quite new to many of the visitors to the Show, who were greatly impressed by the utility of this form of construction, especially when they realised that concrete is not only easily cleaned and therefore sanitary, but that it is fire-proof, rot-proof and vermin-proof.

Among other products exhibited by this Company were concrete fence posts and paving slabs.

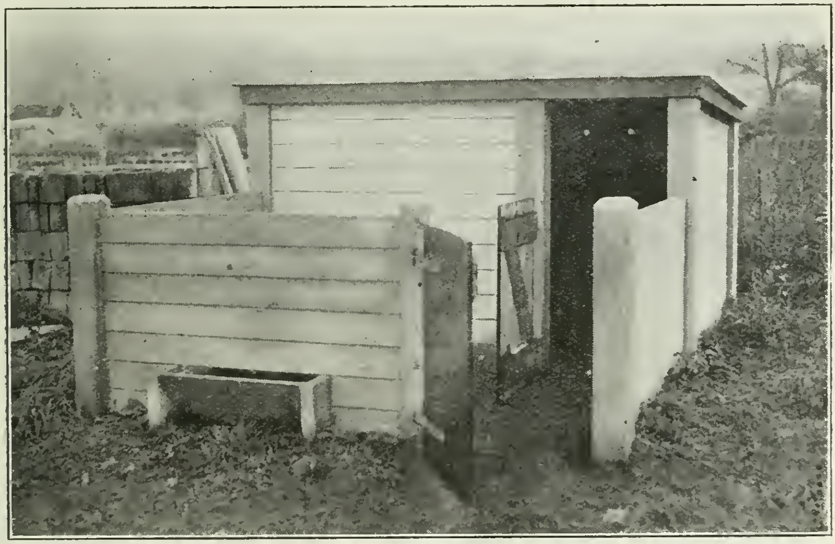


Fig. 3. A Concrete Pigsty. A Good Example of this Method of Construction.

The stand of the *Wharf Lane Company* also attracted a great deal of attention. This firm, although comparatively young, is now very well known in the South and West of England, and has made a speciality of concrete for the estate and farm.

The stand was surrounded by concrete fencing of various kinds, prominent among which was the Company's specially designed fence post with stay which admits of the use of netting fencing as well as plain wire. The posts of the fence in front of the stand were made to match a stone memorial, and had every appearance of being composed of the original material. Another prominent feature was a very fine four-light Elizabethan window, seen on the right in *Fig.* 4, of the same kind of concrete. This matching of any particular stone is another of the firm's specialities. At the side of this was a simple cottage window with a frame of concrete, the latter being built up of "Winget" 18-in. blocks. This window will be seen on the left of *Fig.* 4.

In the centre of the stand was a cow-stall (*Fig.* 5), which naturally proved of great interest to estate agents and farmers. This cow-stall is made so that it can be easily fitted up, the floor being laid by an ordinary mason. Those who have equipped their cow-houses with stalls of this description are loud in praises

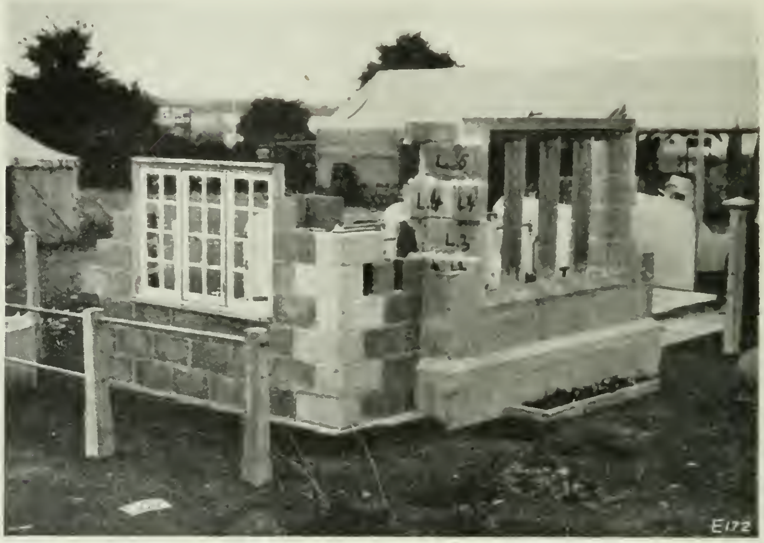


Fig. 4. Two Concrete Window Frames and Concrete Block Walling.

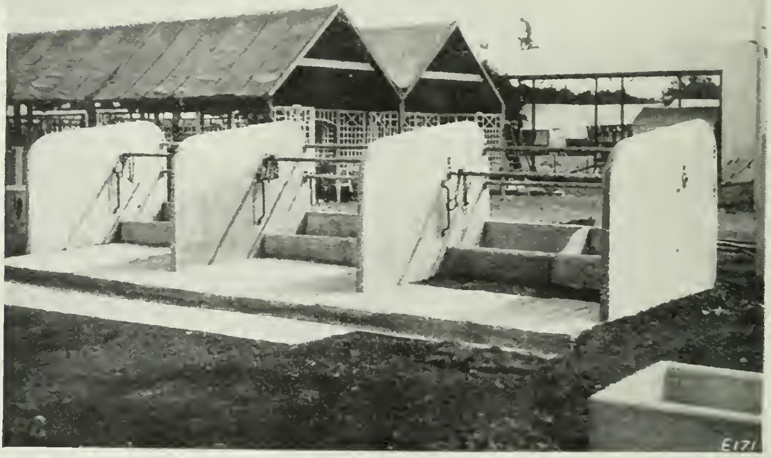


Fig. 5. Concrete Cowstalls with Mangers and Gutter. Portion of a Concrete Donkey Trough is seen in the Foreground.

of their sanitary qualities, as they are easily cleaned and impermeable to liquid manure.

Other exhibits included drinking troughs, both plain and with ball valve boxes, well linings, pipes, gulley kerbs, dairy shelving and breeze floor joists.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

ARTIFICIAL ROAD MATERIAL.

"Kunststein-Strassenpflaster," by Dr. J. Kilnkmüller, Parts I and II.

Verlag der Tonindustrie-Zeitung, Berlin N.W. 21. Price 7.50 Marks each part.

The cost of natural stone delivered on to the roads in some localities is now so high and it is so difficult to procure, that artificial road material is demanding attention, particularly in Germany. A pair of small pamphlets on the subject make some interesting suggestions and describe the manufacture for this purpose of bricks made of common clay, stoneware clay, and of a mixture of granitic gravel bonded with clay and burned. Unfortunately all these materials are more costly than the natural stones in this country and their chief recommendation is in the much greater durability of some of them. Even then, it is difficult to believe that "vulcanal," i.e. granite crushed to powder, fused at 1700° C. and then cast in moulds, can really be an economical substitute for natural stone.

Some of the blocks and slabs made of slag or various kinds of concrete are much more practicable, but the descriptions of these are poor and in some cases inaccurate. It is interesting to note that broken glass is seriously recommended as a road-surfacing material, the glass being crushed, compressed into blocks and burned at 1250° C. before use.

If Germany is really so badly off for road materials as a study of the materials recommended in these pamphlets implies, then are her troubles truly great. At the same time, as Germany has little coal, and that of indifferent quality, it is difficult to understand the recommendations to use what amounts to special forms of pottery for the roads.

The second pamphlet deals with the relative durability of various road materials, and whilst no very definite conclusions are stated, it seems clear that the author considers "vulcanal slabs" to be the best in every respect, except price. The results of tests and costs of ten different road materials are tabulated and the materials are in the following (decreasing) order of suitability: slag bricks, vulcanal blocks, vitrified bricks, clinker bricks, asphalt, best stone cubes, cobble stones, concrete, hard wood and soft wood blocks. The basis on which the relative values of different properties is founded is scarcely satisfactory to British minds, and a better method of calculation would be more fair to concrete blocks. A study of the relative values of the blocks as shown by certain of the proposed tests gives results which seem to indicate that the conclusions reached by the author are founded on samples of indifferent quality.

A TECHNICAL DICTIONARY.

Guide Plumon : Béton Armé. Dictionnaire de termes Français-Anglais-Italien. Vol. No. 28.

Paris : Libraire Polytechnique Ch. Béranger, 1920.

All who wish to keep pace with modern developments in concrete and constructional engineering must, of necessity, read one or more of the various foreign journals and must usually, at some time, require the aid of a French or Italian technical dictionary. The ordinary dictionaries are largely useless when terms relating to concrete and engineering are concerned, but a well arranged dictionary dealing solely with these subjects is of great assistance.

A little pocket dictionary has just been published in France which is excellent.

The work is divided into 97 sections, each dealing with a definite subject and numbered to facilitate reference. Each section is again subdivided so that each word can be referred to by its section number and letter. There is a considerable number of illustrations which greatly add to the value of the work, though it is unfortunate that one illustration should appear in seven different pages and several others appear twice over.

There are three indexes, but they are not at the end of the volume and are difficult to find quickly. If the pages had been cut so as to enable the thumb to be placed on the desired index it would have greatly facilitated reference without seriously increasing the cost.

Some of the additional matter is hopelessly incomplete; only three English firms engaged in reinforced concrete work are mentioned and of these only one can be said to be well known; only one English cement manufacturer is named and no concrete English mixers (bétonnières) or consulting engineers are inincluded! The "methods of pronouncing English" are seriously misleading; several of the pronunciations suggested would be quite unintelligible to the average Englishman.

This little dictionary is a good beginning; it has been designed so as to facilitate a revised edition being published at a minimum cost. Hence, we can only hope that the new edition will be revised by someone better acquainted with the English language than those at present responsible, and in the meantime we can recommend it to all who can use it.

CALCULATIONS FOR REINFORCED CONCRETE WITHOUT THE USE OF FORMULAE.

"Calcul du Ciment Armé sans formules algébriques." N. de Tedesco. "Constructeur du Ciment Armé."
Paris, 1921. Price 20 francs.

Not everyone who ought to make calculations respecting the dimensions of various details to be executed in reinforced concrete has the necessary mental equipment for doing so. Algebra is a wonderful mental implement, but requires much skill in use and must not be applied too mechanically or serious errors may be made. Hence any method which avoids the use of algebraic formulae should come as a boon to many users of reinforced concrete, and for this reason a recently published book by N. de Tédesco will be welcomed by French concrete workers, and an English translation—properly adapted to English conditions and measures—would be equally useful to British concrete workers, though the labour involved in recalculating the large mass of figures into English measurements and to correspond to English regulations would scarcely be repaid by the profits on the sale of the book.

The author's contention is simple and admirable; it is that designers and builders of concrete structures—especially those who are restricted by various local by-laws—should be provided with a simple arithmetical means of making the required calculations.

The "scheme" of the work consists of a brief description of each problem involved, e.g. calculating the moments of a loaded beam, followed by a table of figures and examples of the use of the latter. The explanations are given in remarkably simple terms, though the author has not wholly escaped the use of algebraic symbols and uses complexes such as P_A without much, if any, explanation in cases where a single letter would have been easier for a beginner.

Within its limited compass the book is excellent.

MEMORANDA.

Concrete Pipes in India.—It is announced that a company has been incorporated in Bombay, under the title of the Bombay Hume Pipe Co., Ltd., with the object of acquiring licences from the Hume Pipe Concrete Construction Co. (India), Ltd., to manufacture concrete pipes under the latter company's patents for sale to Messrs. Tata & Sons. Ltd. The new concern is to take over a factory in working order at Jamshedpur, and to establish another factory at Bombay. The whole of the capital of the new company has been underwritten by the Tata Construction Co., Ltd., who will act as its managing agents. The Hume Pipe & Construction Co. (India), Ltd., is considerably developing its activities in India, and in addition to a large factory in full working order at Seebpore (Calcutta), where pipes to the value of several lakhs of rupees are being made, a factory is nearing completion at Mandalay (Burma), for the supply of the pipes for the new water supply to that city, and another factory is nearing completion at Korari (Jhansi).

Reinforced Concrete Calculations in a Nutshell.—By Joseph T. Piggott. A book intended for Architects, Engineers, Builders and Designers of Reinforced Concrete work, containing the 1909 L.C.C. Regulations for Reinforced Concrete, together with a number of rules and other calculations. Published by E. and F. N. Spon, Ltd., 57 Haymarket, S.W.1. Price 3*s*. 6*d*.

QUESTIONS AND ANSWERS RELATING TO CONCRETE.

In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—Ed.

Question.—T. F. B. writes :—Can you give me any information on the subject of lightning conductors on Reinforced Concrete Chimneys, and may the reinforcement be utilised to make a safe and an efficient conductor.

Answer.—The question of lightning conductors is not so well understood that it is possible to be dogmatic as to what is good and efficient, because it is of course only rarely that a chimney is tested in this way. Seeing, however, that the vertical reinforcement actually forms a low resistance conductor from top to bottom, it is very doubtful whether the lightning would not make use of this, even where a separate copper conductor is provided.

A reinforced concrete chimney built off Drury Lane in London, which was 150 ft. high, utilised the vertical reinforcement as lightning conductors; four of the rods being screwed at their upper ends and having copper spikes some 3 ft. long screwed on to their ends. The bottom ends were connected electrically to " an earth " of the usual copper plate construction buried in the ground. These rods were connected by lapping at the joints throughout the chimney, being wired together at the laps. The horizontal reinforcement was also wired to the vertical rods, but beyond this no special precaution was taken to secure good conductivity. When the chimney was completed the electrical resistance was tested between the spikes at the top and the earth, and found to be only a very small fraction of an ohm. This chimney was built about 1912, and has given complete satisfaction.

MEMORANDA.

Bristol University.—We understand that some very interesting reinforced concrete work is being carried out in connection with the new buildings for the Bristol University, various types of reinforced concrete construction being employed, including hollow flooring over large spans, vaulted work, staircases, galleries and foundations. The reinforced concrete is on the Hennebique system to the designs of Messrs. Mouchel Partners, Ltd. The architects for the building are Messrs. Oatley & Lawrence, FF.R.I.B.A., of Bristol.

South Shields.—The South Shields Corporation is experiencing considerable difficulty in connection with its housing scheme, both in regard to the high prices in the tenders received and the difficulties of obtaining adequate supplies of bricks within a reasonable period of time. In order to overcome these difficulties, the Housing Commissioner for the district has requested the Housing Committee of the Corporation to adopt a system of concrete construction.

Housing in Australia.—The use of concrete in house building, recently introduced in Sydney, is increasing in Australia, as it has proved so economically successful.

Roads in Australia.—The Brisbane City Council is applying to the Queensland Government for permission to borrow £100,000 for the construction in reinforced concrete of roadways in such thoroughfares of the city area as are called upon to carry heavy traffic.

Bridge over the Spey.—The Moray County Council has decided to erect a reinforced concrete bridge over the River Spey at Advie, in place of the structure washed away last year. The new bridge is to cost £7,000.

NEW METHODS OF CONSTRUCTION.

In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.—Ed.

McLEOD'S UNIT SYSTEM. SOMETHING SIMPLE AND NEW IN CONCRETE CONSTRUCTION.

The following brief outline of a new method of erecting monolithic concrete walls will be of interest to practical men, and the system merits the consideration of those who are working in connection with or on behalf of the national housing problem.

This system, the invention of Mr. Wm. McLeod, of Wanganui, New Zealand, consists briefly in the pouring of a wet mixed concrete into a cavity wall composed of small, light, hollow concrete units to which the term " structural tiles " is applied. These are laid up *without mortar*, take the place of forms and become part of the finished wall. Thus this method is more than a new design of block, it is a new form of construction.

The several units are of special design, as seen in *Figs.* 1 and 2, and provide means for placing reinforcement where desired. When arranged in the wall free access is given to the poured concrete which fills up the hollow spaces and forms, with the " tiles," a monolithic structure.

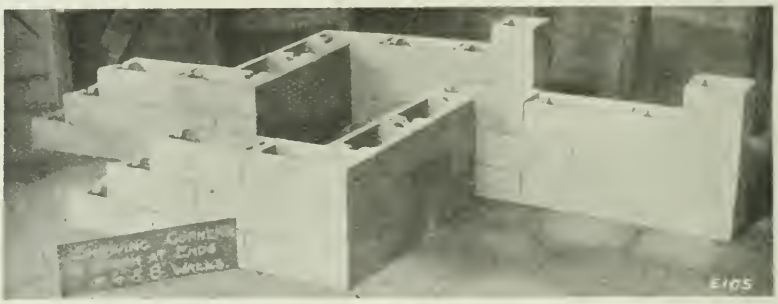


Fig. 1. Walls.

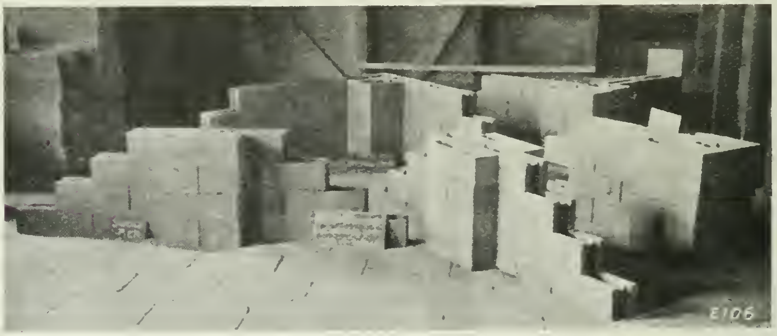


Fig. 2. Walls and Piers.

Fig. 3 shows the arrangement of the units to form walls of various thicknesses, those in the illustration ranging from 4 ins. to 2 ft. 3 in. In *Fig.* 4 is seen the method of constructing columns on this system, while *Fig.* 5 illustrates the way in which arch work is carried out. Here the units are brought up to the centering as indicated, and the openings left between the former and the latter are covered by timber facing-pieces, not shown in the photograph, nailed to both sides of the centering and forming a casing which retains the concrete when the wet mixture is poured through the " tiles " from above. Facing boards are also fastened on each side of the wall to cover the openings caused by the special arrangement of the blocks. *Fig.* 6 shows the method of dealing with openings such as windows and doorways. Temporary shuttering is placed in position to support the lintel units until the contained concrete has set, when the lintel becomes monolithic. Reinforcement, as indicated in the illustration, is advisable in the case of door and window heads.

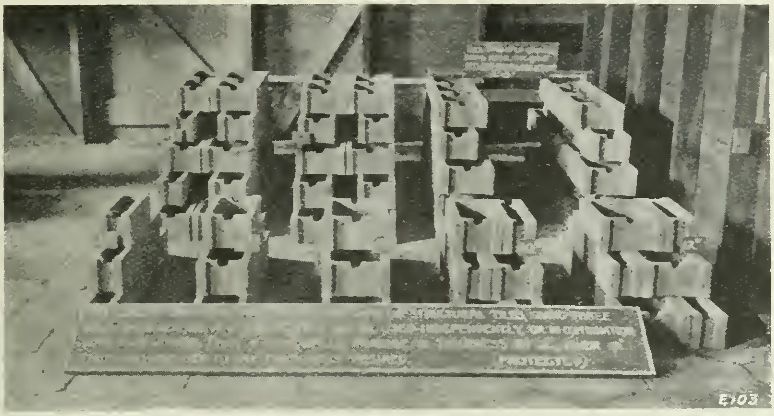


Fig. 3. Showing Various Thicknesses of Walls.

The principal claim put forward by the inventor is that of the reduction of cost in building operations, and the means by which this will be brought about are said to be three in number :

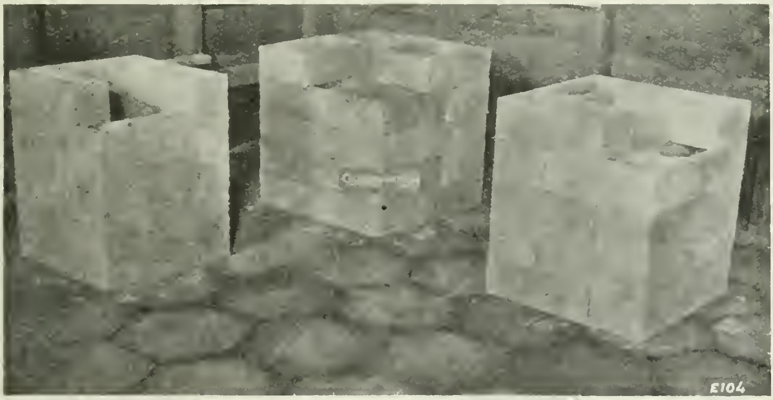


Fig. 4. Showing Pillars.

(1) By the elimination of shuttering and other costly features of construction.

(2) By the use of highly developed power machinery and well-equipped factories for the automatic production of the units, or, in other words, mass production. .

(3) By the simplicity and speed with which the units can be erected by unskilled labour.

With regard to the second point mentioned above, this is only the proposed adaptation to building methods of means already applied in this country to certain other industries. Such machinery and factories manufacturing concrete units have for many years been established in the United States of America, and the gradual extension of this method of production in that country indicates its success and is a measure of the increased demand for this class of product. As an example of speed of production there is one machine which turns out 3,000 blocks 12 in. × 8 in. × 5 in. in a nine-hour day, or 2,667 in eight hours, three being made at each operation.

Coming to the third point, since these units are built up without mortar the stonemason and bricklayer are entirely eliminated, and practically the whole of the work can be done by previously unskilled labour. Of course it will be evident that no great saving in cost of building would result from merely employing unskilled labour in place of skilled, but an important point is that a large number of untrained ex-service men could be absorbed into the industry. It must not be forgotten, however, that the setting out and the supervision of the work will always require a skilled and competent man.

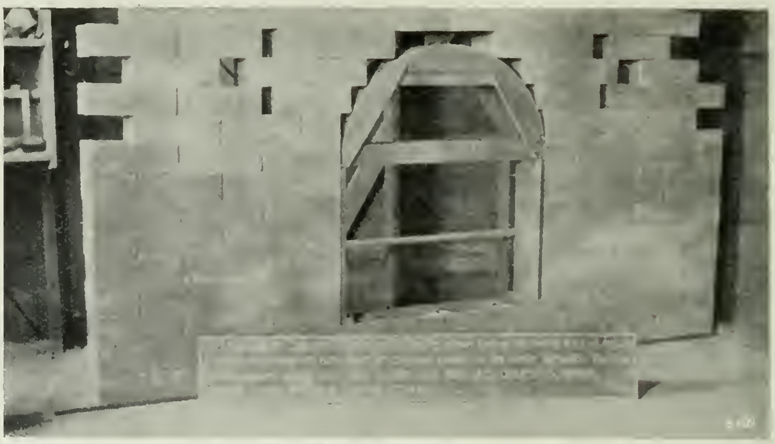


FIG. 5. SHOWING METHOD OF FORMING ARCH WORK.

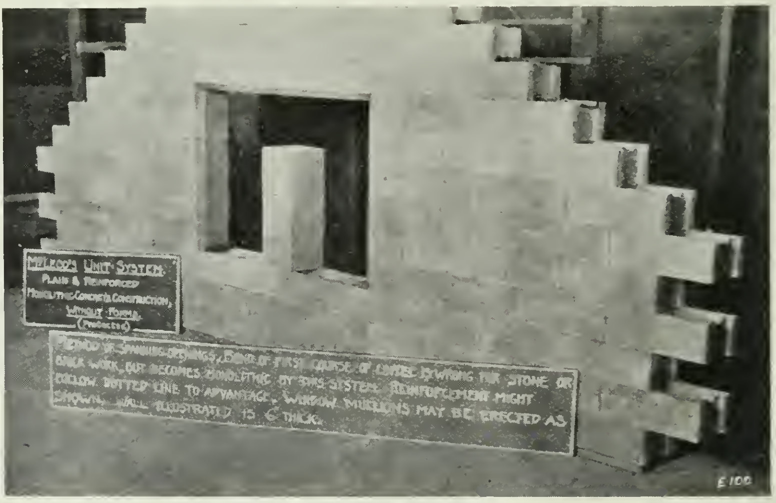

McLEOD'S UNIT SYSTEM.
PLAIN & REINFORCED
MONOLITHIC CONCRETE CONSTRUCTION,
WITHOUT FORMS.
(PROTECTED)
METHOD OF SPANNING OPENINGS, ... FIRST COURSE OF LINTEL SHOWING FOR STONE OR
BRICK WORK, BUT BECOMES MONOLITHIC BY THIS SYSTEM. REINFORCEMENT MIGHT
FOLLOW DOTTED LINE TO ADVANTAGE. WINDOW MULLIONS MAY BE ERECTED AS
SHOWN. WALL ILLUSTRATED IS 6" THICK.
E100

FIG. 6. WINDOW OR DOOR OPENING.

The system appears to have been well thought out, and it is claimed that it is capable of being adapted to every requirement of ordinary building construction.

All communications in regard to this system should be addressed to Mr. A. B. Searle, The White Building, Fitzalan Square, Sheffield.

NEW CONCRETE MACHINERY.

TWO NEW BLOCK-MAKING MACHINES.

A CONSIDERABLE item of expense where small units made on the site are used for concrete construction, and one that can never be entirely eliminated where a central plant is used for the manufacture of the units, is the cost of the labour necessary to carry the blocks from the machines to the place where they are to mature and from thence to the place where they are to be used in the building. If the blocks are carried any distance the cost of carrying them backwards and forwards often exceeds the cost of making them, for more men are required to keep the machines clear than for the actual manufacture of the units. There is here a fertile field for reducing the cost of concrete building, and it is with the object of lessening this unproductive expenditure that the Martin-Harvey Engineering Co., of 116 Victoria-street, Westminster, S.W.1, have put on the market their Type "C" and "G" block-making machinery illustrated herewith.

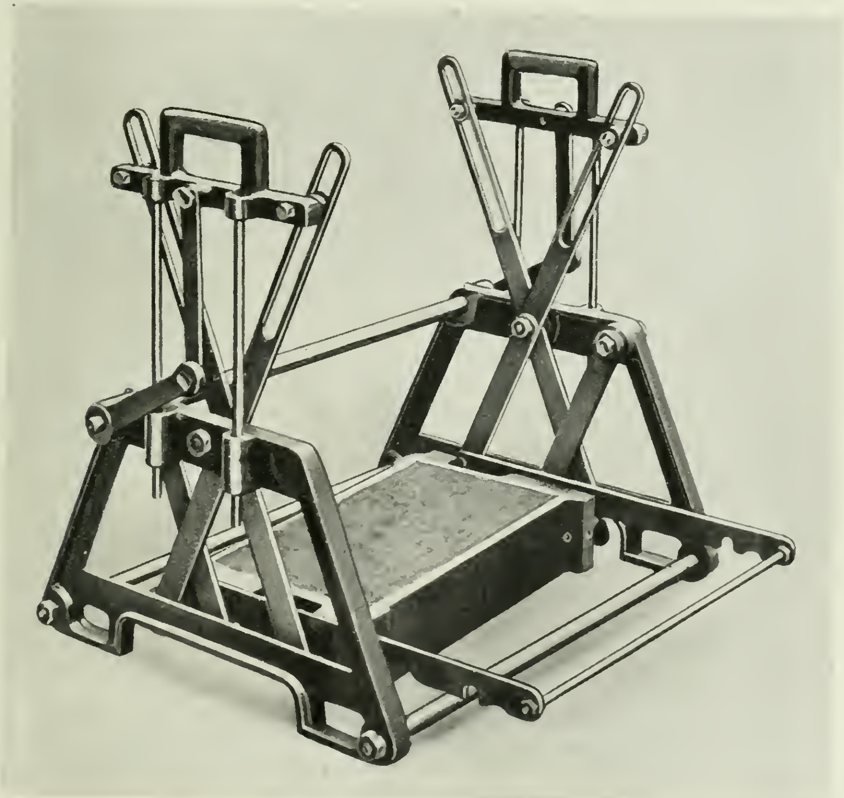


FIG. 1. TYPE C.

The illustrations explain the operation of the Type "C" machine. *Fig.* 1 shows the mould filled, and *Fig.* 2 shows the mould open ready for the removal of the machine. The system is practically a reversal of the usual method of making blocks, for while the ordinary practice is to carry the finished blocks away from the machine, in this case the machine is carried away from the blocks, which are left to mature where they are made, not being handled again until they are placed in position in the building.

The use of a large number of pallets is thus obviated, for the blocks can be made on boards or any flat surface and it is not necessary to handle them until they are hard. After the mould is filled and tamped the sides are released by the operation of the handles at the end (as shown in *Fig.* 2), and the whole machine is lifted bodily and carried to where the next block is wanted. The mould measures 18 in. by 9 in., and blocks can be made in any thickness up to 4½ in. The mould can also be made to manufacture coping or other special shapes, or five concrete bricks of standard size can be produced at one operation. The machine is also made, on the same principle, mounted on wheels, and in this case a tamping plate is fitted. By a judicious organisation to ensure that the blocks are manufactured and left to mature in close proximity to the place where they will be wanted, there is no doubt that a considerable saving in labour costs can be effected by this type of machine.

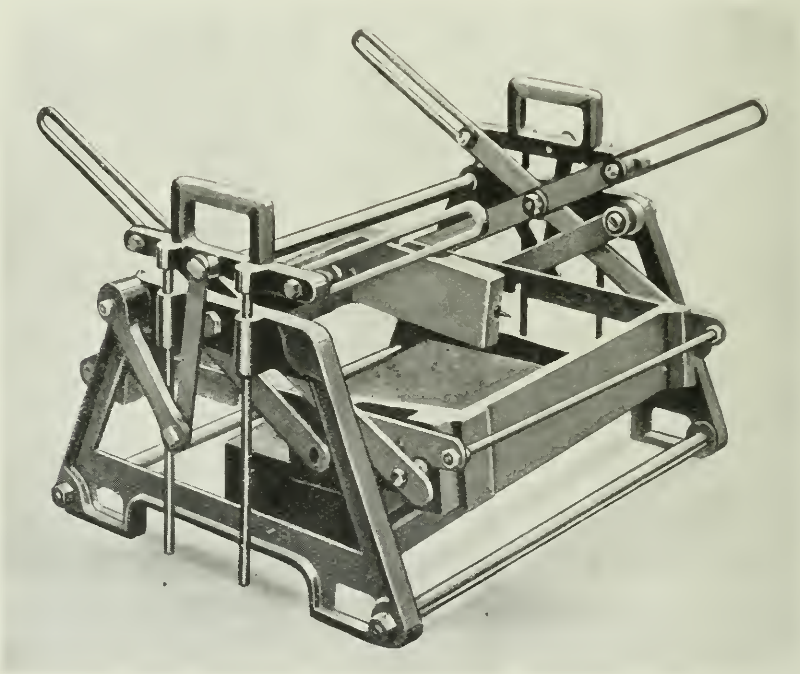


FIG. 2. TYPE C.

The Type "G" machine, illustrated in *Fig.* 3, is on the same principle as the Type "C" machine, *i.e.*, it aims at the elimination of the necessity for carrying the blocks away from the point of manufacture for curing, but is designed for a larger output and is fitted with an ingenious eccentric movement whereby the blocks are automatically compressed. Four moulds are employed, fixed on the ends of rods which are carried on a pair of rotating castings mounted on a heavy fixed axle. On this axle between the castings is securely mounted a cam or eccentric, with its major and minor axes approximately opposite each other in a horizontal plane. The back plate of each mould is movable and carries a stout rod with a roller at its inner end which bears on the eccentric. In the filling position (the right in the illustration), the roller is opposite the minor axis of the cam, and the mould is at its widest. It is filled loosely, and the pallet is placed on top, and held securely in place by a pair of swinging brackets. By means of a vertical capstan and suitable reduction gearing the whole appliance is then rotated through 90° till the next empty mould comes into the filling position. As the roller travels round the cam the eccentricity of the latter causes the back of the mould to be forced against the contents, and by the time each mould has come diametrically opposite the filling position (the left in the illustration), the block has been compressed to the requisite dimensions. When the mould has completed a three-quarter circle, and the block is ready to be placed on the ground, the pallet forms the mould base, so that all that is necessary is to open the mould and wheel the machine along to where the next block is to be placed. The machine in the standard size is arranged to mould blocks 18 in. by 9 in., by any thickness up to 6 in., but can be adapted for almost any type of solid block or slab, while means are provided for giving any requisite degree of pressure depending on the nature of the aggregate in use.

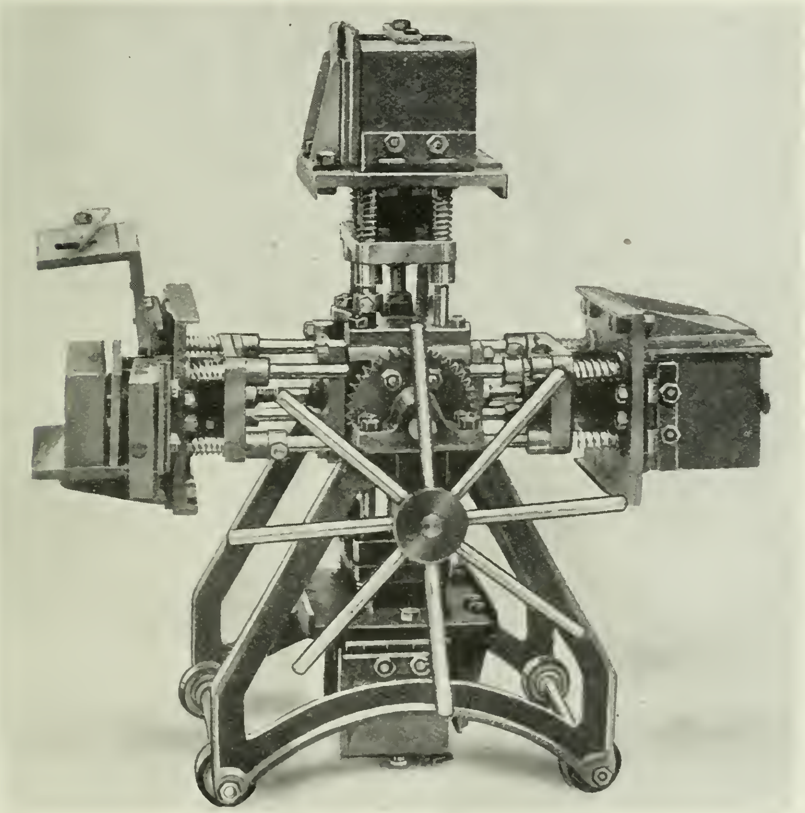


Fig. 3. Type G.

Holes in Concrete.—The oxy-acetylene blowpipe has been found most useful for making holes in concrete. The concrete must be attacked from below, which is rather a serious limitation on the utility of the method. Holes in concrete 12 in. thick can be made in ten minutes each. They are of conical form, 6 in. diameter at the bottom, tapering to 1 in. at the top in the thickness named. The method is not only quick, but less liable to break up the mass than by jumping the holes.

SOME ABSTRACTS FROM THE FOREIGN PRESS.

A CINERARY MONUMENT IN REINFORCED CONCRETE.

An interesting use of reinforced concrete is the cinerary monument designed by M. Vozeille. As shown in the drawing, it consists of a tower, the greater part of which is below ground level. The walls are 8 in. thick and are provided with ledges to carry shelves on which the urns are placed. These walls appear to be very light, but if the vertical reinforcing rods, $\frac{3}{8}$–$\frac{5}{8}$ in. diameter, are placed $1\frac{1}{2}$ in. apart and the horizontal ones are placed about 5 in. apart, they will resist an inward pressure of 200 lb. per sq. ft., which is far in excess of what is likely to be required.

The reinforced shelves are one-fifth of an inch thick and will support a load of 880 lb. They are supplied with the monument and are kept in it until required for use.

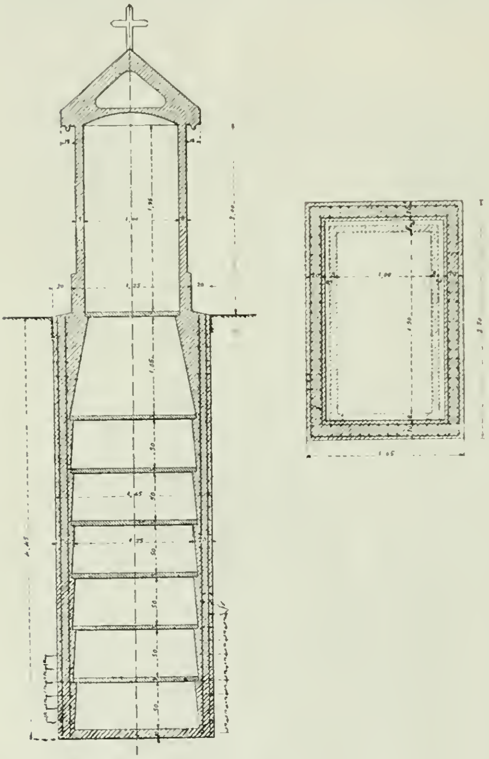


Fig. 1.

The portion of the monument which is above-ground is largely precast with the exception of the framework at ground level, which is made on the site.

There are six compartments, each 6 ft. × 3 ft. 6 in. by 1 ft. 8 in. deep, with two smaller but deeper ones above. The sides of the monument are used for the inscription.—*Le constructeur de Ciment Armé.*

THE STANDARDISATION OF HOLLOW BLOCKS.

The present state of affairs, in which every inventor imposes a different size and shape of block on the community, may have the advantage of freedom of design, but it imposes a real difficulty in the way of progress, writes Dr. Emperger. In brickwork, every architect and engineer can rely on the unit of construction being of a definite size, but with hollow blocks made of concrete they must put up with a large number of special sizes and shapes which unduly increase the cost of production as well as reduce the output. If hollow blocks of concrete are to enter into general use in the same way as bricks, they must conform to a certain standard size, special shapes and sizes being treated as "extras" and kept at a minimum.

In the first place, all concrete blocks which are larger than a brick should be of such dimensions as to bond well with bricks, and the number of bricks with which they correspond should be clearly indicated.

If we express the dimensions of a common brick as l, b, and h respectively and those of a hollow concrete block by L, B, and H, suitable limits for the latter will be found if

$H = 2h$ or $3h$, $B = 1\frac{1}{2}b$ or $2b$ and L is a definite multiple of B and preferably is $2B$ or 9 in.

Under these conditions two shapes will suffice for most work, though a half-block and a closer may be needed. Some firms also consider that window blocks are also needed. In designing any building, the architect usually arranges that its chief dimensions (including spaces between windows and doors) shall be simple multiples of l, b and h, and it is, therefore, necessary that the manufacturers of hollow blocks and of hollow block machines should bear this fact in mind.

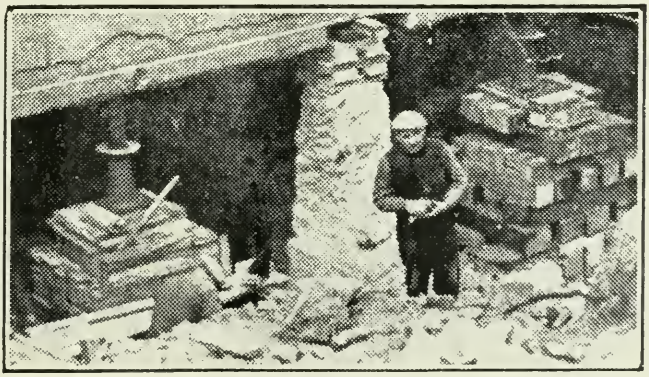
Even if it is decided that there is no need for hollow blocks to bond exactly with brickwork, it is still necessary that the blocks should have their dimensions standardised, so that architects may readily calculate how many are required for a given piece of walling, and also how to fit the blocks to the openings or wall-dimensions desired. Dr. Emperger suggests that a very convenient unit is to adopt $B = 20$ cm. as the standard (if a corresponding standard were adopted in the United Kingdom, B would probably be 9 in.) and he would require architects and builders to make all openings for windows, doors, etc., a simple multiple of this figure so as to avoid the necessity of cutting the blocks.

With B established, L is easily arranged, for it has long been agreed among architects and builders that $L \times 2B$ is the most useful and beautiful form of block, though where B is large it may be desirable to regard $L = 1\frac{1}{2}B$ as more satisfactory. This is due to the fact that the chief object of using hollow blocks is to save material and labour whilst still retaining the necessary compressive strength. Hence a block must be as large as possible without being too heavy for a man to lift it readily and to place it in position on the wall without difficulty. Between this largest block ($L = 2B = 18$ in.) and the smallest permissible hollow block ($L = 2B = 9$ in.) there is little margin, and in practice $L = 1\frac{1}{2}B = 13\frac{1}{2}$ in., is probably the best size for general use in spite of its awkward measurement. If the metric system is used $B = 24$ cm. would be preferable as this is divisible by 2, 3 and 4 without remainder.

The production of a special block for reveals seems to be essential, but with care the number of shapes required can be reduced to three, with which walls of any required size may be built.

At present the hollow block industry is hindering its own progress by the multiplicity of its shapes and systems. The sooner the former are reduced to a minimum so far as wall-area is concerned the better, there will even then be ample scope for novelty in design. There is no need to fear that the standardisation of hollow blocks will restrict the industry. On the contrary it will enable architects and builders to use these blocks.—*Beton u. Eisen.*

AN INTERESTING JOB AT BRUSSELS



It was recently necessary to lower one of the streets of Brussels by about 6 ft. 6 in., and thereby reduce its inclination from 10 to 5 per cent. One part of the street was lowered in the ordinary manner, but the other part, 130 ft. in length, adjoining the rue Ravenstein, was in the form of a monolithic slab supported longitudinally on two walls and laterally on two rows of pillars with a terminal wall at each end. This slab weighed about a thousand tons.

The drains and pipes for fresh water and electric cables had to be destroyed and rebuilt, but the massive slab was cut loose by shears and chisels, the reinforcement being cut with oxy-hydrogen blow pipes. Forty-two bottle-jacks were then introduced and the slab gradually lowered. All the jacks were operated simultaneously, a man being in charge of each and orders were given by whistles.

Notwithstanding the slope of the street, which imposed a serious slipping tendency, the lowering was effected without any accident and precisely according to plan.—*Revue du Béton Armé.*

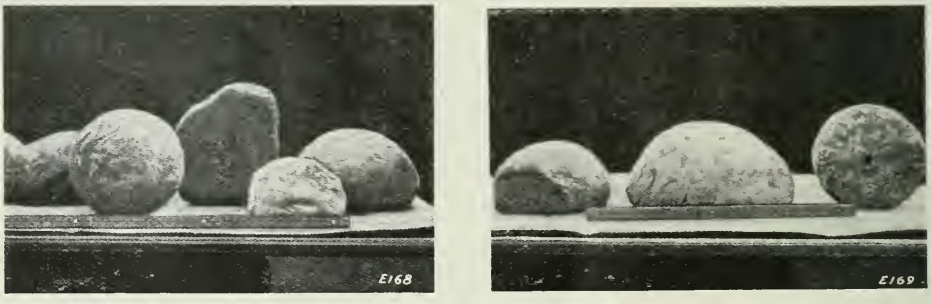
CEMENT NOTES.

The following Notes regarding Cement have been abstracted from our Foreign contemporaries.—Ed.

The Balling of Cement.

The formation of balls when Portland cement sets is due to a disturbance of the homogeneity of the cement by the addition of water, as a result of the presence of impurities which act as nuclei and facilitate the formation of new crystals. These impurities need not have any direct chemical action on the cement as have calcium chloride, soda, etc.; it is sufficient if they withdraw water mechanically from the paste and so increase the rate of setting. Consequently "balling" may be produced by sawdust, pieces of bread, flour, paper, cloth and other fibrous materials. Sometimes the impurity expands and so causes the balls to crack.

All cements do not "ball" with equal facility; some appear to have a composition—not definitely known—which increases the balling tendency, whilst with others the presence of too much gypsum increases the defect. Cements which do not set in less than 3–4 hours do not ball on the addition of glue, sawdust, etc., but do so readily if calcium chloride or soda is added.



Balls from a Cement Store.

Portland cement sometimes balls when stored ready for use, if the roof or sides of the bin or shed are not water-tight. For instance, in one store a leak developed in the roof and admitted the rain; some days later when the cement was taken out of the store it contained a number of balls such as those shown in the accompanying illustrations. In the latter, the mark left by the original drop of water forming each ball is clearly seen. When these balls had been kept for some months, they were found to have a radial structure and to be distinctly crystalline—a condition quite different from that of cement mixed with water and allowed to harden in the usual manner.—Dr. Killig in *Zement.*

The Nominal and True Fineness of Cement.

The standard specification for Portland cement specifies that it shall not leave more than 3 per cent. residue on a No. 76 sieve, or more than 18 per cent. on a No. 180 sieve, but this does not necessarily imply that of several cements the ones with a smaller residue contain a larger percentage of active cement than the others. As a matter of fact the really active particles are far smaller than can be represented by any sieve, and many years ago Michaelis expressed the belief that if a sieve with apertures one-fifth of the diameter of standard mesh could be made, the whole of the active particles of cement would pass through it.

In order to gain a further insight into the proportion of particles of different sizes, Dr. H. Nitzsche of Frankfurt-a.-M. has treated 21 cements—including Portland, Iron and Slag cements—on sieves having 75, 125, 175 and 250 meshes per linear inch. As might be expected, there is no relationship whatever between the percentage of residue on each of these sieves.

The residues were examined under the

microscope, using a magnification of 150 and 380 diameter for the coarser and finer residues respectively and the various percentages of particles of various sizes were counted. Notwithstanding every effort to reach a definite conclusion, however, it was conclusively shown that an exact separation of the particles cannot be obtained by any method of sifting. The percentage of residue on each of the four sieves varies within very wide limits with each cement tested, even when all conforms to the standard specification, so that it is impossible to suggest an extension of the standard so as to limit the residues on each of a series of sieves.

In short, neither the residue on one or more sieves, the average residue, the micro-measurement of the particles of various sizes, nor the total number of particles, gives any correct idea of the true fineness of the cement. On the other hand, comparative figures for fineness can be obtained by measuring the total area of all the particles of less than a given diameter, calculating the percentage of these finest particles relative to the whole of the particles which pass through any given sieve and dividing this percentage by the percentage of residue on the sieve. Comparable figures are obtained for any sieve, and if the finest of the material which passes through the 250 sieve is taken, a figure proportional to the true fineness (*m*) can be found as follows :

$$m = \frac{\%\text{ of the finest particles below 0·0037 mm. dia.}}{\%\text{ of material passing through 250 sieve}}$$

Thus, four cements examined gave :

	1	2	3	4
(*a*) Percentage number (relative to total number of particles below 0·003 mm. diam.) . . .	73·5	86·1	78·5	76·7
(*b*) Percentage by weight of material passing through No. 250 sieve . .	70·82	92·03	79·01	75·49
a ÷ b = .	1·04	0·93	0·99	1·01

Order of fineness : Fourth, First, Second, Third.

Dr. Nitzsche's investigations show that, using these methods of calculation, whichever sieve is used the cements be examined are always placed in the same order of fineness, i.e., there is in the cement as a whole almost the same proportion of particles which pass through the 250 sieve as the proportion of particles less than 0·0037 mm. diameter in the portion passing through the 250 sieve.

From this Dr. Nitzsche concludes that the fineness (*m*) of a cement may be expressed by the ratio

$$m = \frac{\%\text{ passing through a No. 250 sieve}}{\%\text{ residue on a No. 250 sieve}}$$

The actual percentage residue on each of the four sieves, the percentage passing through No. 250 sieve and the degree of fineness (*m*) are shown in the following table :—

Cement No.	Residue on Sieve No.				Through 250	*m*
	75	125	175	250		
1	1·29	9·54	17·37	29·18	70·82	2·43
2	0·41	1·41	2·25	7·64	92·36	12·09
3	0·15	2·79	8·17	20·99	79·01	3·77
4	0·20	4·57	11·15	24·51	75·49	3·07
5	0·25	3·46	8·91	23·93	76·07	3·20
6	2·10	8·97	14·79	27·41	72·59	2·64
7	1·07	5·65	12·78	27·30	72·70	2·66
8	0·30	0·68	1·52	9·94	90·06	9·06
9	0·34	3·74	9·39	23·10	76·90	3·33
10	1·44	3·27	4·89	11·83	88·17	7·47
11	0·26	1·35	4·10	16·06	83·94	5·22
12	0·70	1·12	1·74	10·08	89·92	8·93
13	0·52	1·62	3·45	14·18	85·82	6·05
14	0·44	1·94	4·88	15·87	84·13	5·65
15	0·37	2·31	5·70	16·66	83·34	5·00
16	0·58	2·17	4·07	12·21	87·79	7·20
17	0·20	1·17	2·04	10·65	89·35	8·40
18	0·18	0·59	2·80	15·02	84·98	5·66
19	0·80	5·90	13·28	26·33	73·67	2·80
20	2·59	10·78	16·95	28·64	71·36	2·49
21	0·67	1·61	4·33	15·67	843·3	5·38

The method is quite simple and if it is generally applicable to all Portland cements it may be of great importance to the future of the industry.—*Zement.*

PERSONAL.

Kelvin Medal.—The presentation of the first award of the Kelvin Medal was made by the Rt. Hon. A. J. Balfour, O.M., F.R.S., in the Hall of the Institution of Civil Engineers, to Dr. William Cawthorne Unwin, F.R.S. The Medal was founded in 1914, principally by British and American engineers, to commemorate the achievements of Lord Kelvin in those branches of science which are specially applicable to engineering.

Crystal Palace Engineering Society.—The "Wilson Premium," for the best paper read before this society during the present session, has been awarded to C. W. Carter, for his paper on "Reinforced Concrete."

CORRESPONDENCE.

Under this heading we invite Correspondence.

Research on Building Materials: The Use of Lime instead of Portland Cement.

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

SIR,—After reading the very practical suggestions which Mr. Alan E. Munby recently gave at the meeting of the Royal Institute of British Architects, I have thought that perhaps the following notes may be of interest, for I do not think they are universally known, although people who have studied the use of lime may be aware of them.

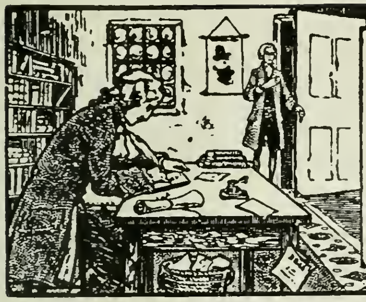
LIME CONCRETE.—While the war was being waged a firm had to put down a concrete floor at their works and had difficulty in obtaining sufficient Portland cement, so they used lias lime concrete and floated it over with Portland cement mortar. This appeared to give a very good floor, and the only objection they had to make was the slow setting of the lime concrete. But, after an interval of three years, the floor sounds hollow here and there, owing to the ¾-in. cement floating not adhering to the lime concrete. It has also cracked, and the surfaces adjacent to the cracks have been badly affected by the traffic. It is a warning not to place cement work over lime concrete, because lime has not sufficient cohesive strength to retain the cement rendering when subjected to traffic. Nevertheless, if cement plastering on a wall is well-keyed it holds the thin coat of lime plaster which is often placed over it.

LIME PLASTERING.—Probably the most fatal objection to the universal use of lime for exterior plastering is that a sharp frost will crumble the work if it follows while the lime plastering is damp, and there are few months in England when one can be sure that the nights will not be frosty. If Portland cement is used, it generally sets sufficiently hard to be unaffected by the frost, except during the severe frosts we get in the depth of winter. Labour is so expensive nowadays that it is a serious matter to do work twice over, even if the material used is much cheaper.

Mr. Munby mentioned that a patent was taken out in 1856 for strengthening lime, a process which doubled the strength of the mortar, " but nobody, to-day," he said, " appears to be conversant with this patent method of strengthening lime." I do not wonder at this invention becoming obsolete, for to whose interest is it to advocate the use of lime made according to an expired patent ? Who will go to the expense and trouble of demonstrating its goodness and utility ? Certainly nobody would get any financial advantage from it. My experience of putting new methods of construction on the market is that no matter how good they are architects are rightly conservative, because of the serious liability which attaches to an architect's adoption of anything which may be detrimental to the structure he erects. It is essential that the uses and the non-detrimental effect of any new material should be advertised, otherwise it will remain unknown, but in the year 1856 there were not the journals which now exist for publishing advertisements. The following incident will better illustrate my meaning : One of the exhibitors at the recent Building Trades' Exhibition at Olympia asked me how to make his invention known to architects. When I told him what he would have to spend before he could benefit both himself and the architects—for his invention was beneficial to the community—he departed shaking his head. Three days afterwards he brought his wife to me, and she told me that I had much better have advised him to give the money to her ! So I suppose this most admirable invention, which is patented, will lapse for want of publicity, like several other inventions which have been introduced to my notice and which would have undoubtedly benefited the building industry.

It is an axiom amongst advertisers that advertisements cannot profitably sell a worthless article, but a worthy article cannot be sold except by advertisement.

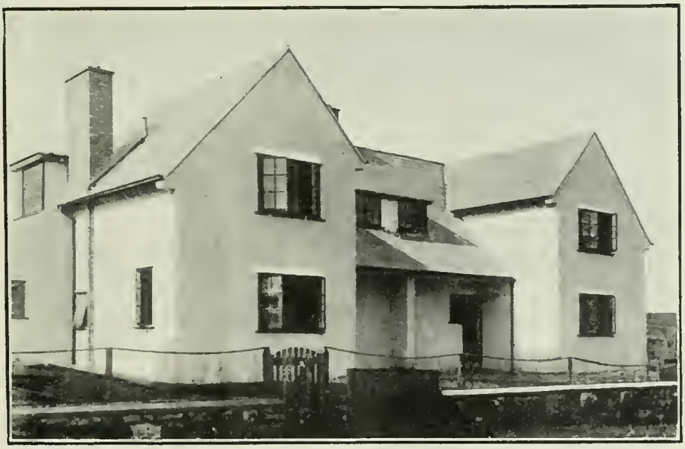
J. H. KERNER-GREENWOOD.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—Ed.

Houses at Port Talbot.—A big housing scheme is being carried out near Port Talbot in connection with Messrs. Baldwins' Steel Works. It was recently decided to put up two good-sized semi-detached houses for managers of the firm, some eight miles away from the main job. Each house was to include an entrance hall, two reception rooms, kitchen and scullery, four bedrooms and bath room, with generous box-room and out offices. The contractors, Messrs. John Laing & Son, of London and Carlisle, had a month in which to complete the houses from damp-course ready for occupation. It meant sending out thirty men and all the necessary materials—chiefly "Winget" concrete blocks, with which both houses were constructed—by lorry every day from Port Talbot; but workmen and foremen alike tackled the task in a sporting spirit, and actually completed the houses, even to boundary walls, gates and electric light, in thirteen and a half days. The houses, it should be added, were designed by Messrs. Culpin & Bowers. The accompanying illustration shows the completed houses.



Front View of Completed Houses.

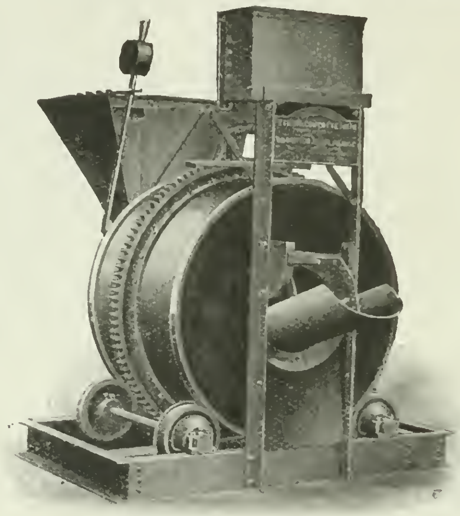
CONCRETE AND HOUSING SCHEMES.

Pittenweem.—Owing to the difficulty it has experienced in obtaining a supply of bricks, the Pittenweem Burgh Council is obtaining quotations for concrete houses.

Stirlingshire.—The Central and Eastern District Committees of the Stirlingshire County Council are making considerable progress with their scheme for the manufacture of concrete blocks and bricks for use on the housing schemes in their areas, and plans for the necessary buildings have now been passed by the Falkirk Dean of Guild Court for the Brickmaking Committee formed jointly by the two Councils. The buildings are of a temporary nature, and include sheds for covering the cement

The "Zenith" CONCRETE MIXER

For BELT DRIVE, STEAM,
COMPRESSED AIR,
ELECTRIC or PETROL.



¾-Yard Mixer, Discharge Side.
Average Output, 225 Yards per 10 hours.

HOLDS
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AGAINST
ALL COMERS,
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BRITISH BUILT THROUGHOUT

JUDGED BY OUTPUT. This Mixer, while not the cheapest in first cost, is beyond doubt the most ECONOMICAL Mixer to employ on your contracts. ITS MASSIVE BUILD renders replacements and renewals a negligible quantity ; its EFFICIENT METHOD of MIXING, combined with its VERY LARGE OUTPUT, makes it the

Best Money Earner Obtainable

therefore, in a *real sense*—THE CHEAPEST.

Specify "The Zenith."

Catalogues on application to:—

The BRITISH STEEL PILING Co.
DOCK HOUSE, BILLITER ST.,
LONDON, E.C.3.

and machinery, drying racks for stacking the concrete blocks whilst they are maturing, and a narrow-gauge light railway track. The site of the works is at Camelon, and the estimated cost of the buildings is put at £1,400.

PROSPECTIVE NEW CONCRETE WORK.

Batley.—*Waterworks.*—The Batley Corporation is seeking Parliamentary powers to construct additional waterworks, etc.

Cheltenham.—*Reservoir.*—The Cheltenham Town Council is considering the question of extending the reservoir at Dowdeswell, and has been recommended to appoint Mr. E. Sandeman as consulting engineer to report on the work.

Hartlepool.—*Sea Defence.*—Sanction has been obtained to an application of the Hartlepool Town Council for a loan of £16,500 for sea defence works.

Hastings.—*Harbour Works.*—The Hastings Town Council has referred to a sub-committee the question of extending the breakwater at the harbour, at an estimated cost of from £50,000 to £60,000.

Ireland.—*Concrete Tank.*—The Belturbet (Co. Cavan) Urban District Council has decided to carry out a water supply scheme for the town, and Mr. P. J. Brady, M.R.I.A.I., of Ballyhaise, has been instructed to prepare plans and estimates for the work, which will include the construction of a reinforced concrete storage tank.

Largs.—*Waterworks.*—The Largs Town Council has decided to apply for a loan for the construction of a new reservoir.

Moray.—*Bridge.*—The Moray County Council has decided to proceed with the erection of a new bridge over the River Spey, at Advie, to replace a bridge washed away last year. The new bridge is to be of reinforced concrete, and the cost is estimated to be about £7,000.

TENDERS ACCEPTED.

Abingdon.—The following tenders have been received by the Abingdon Town Council for the erection of 50 houses :—Building and Public Works Construction Co. (Swindon), £34,255 12*s.* 6*d.* ; J. E. Billings & Co., Ltd. (Oxford), £36,000 ; Benfield & Loxley, Ltd. (Oxford), £37,184 ; Hinkins & Frewen (Oxford), £37,500 ; Say & Co., Ltd. (London), £38,230 ; A. Cox & Sons, Ltd. (Abingdon), £38,722 ; E. Organ & Son (Oxford), £39,593 ; Kingerlee & Sons (Oxford), £39,900 ; A. L. & H. W. Chown (Northampton), £41,160 ; Unit Construction Co. Ltd. (for concrete houses), £41,763 ; S. Hutchins & Son (Oxford), £41,763 ; Bartlett Bros. (Witney), £42,760 ; Abingdon Associated Builders (Abingdon), £42,790 ; Guest & Goodall, Ltd. (Ascot), £46,379 8*s.* 8*d.* ; Winkworth & Winkworth (Ipswich), £46,973 3*s.* 8*d.*

Ashby-de-la-Zouch.—The Ashby-de-la-Zouch Rural District Council has received the following tenders for the erection of 26 houses at Measham :—B. Copeland (Leicester), type "A" houses, £1,296 18*s.* 2*d.* per pair, and type "B" houses, £1,540 7*s.* 6*d.* per pair ; B. Cole (Leicester), £1,399 and £1,654 ; Southam, Roones & Aldridge (Tamworth), £1,410 and £1,650 ; T. Lowe & Sons (Burton-on-Trent), £1,507 and £1,777 ; G. Hodges & Son (Burton-on-Trent), £1,522 and £1,790 ; T. Rowbotham (Birmingham), £1,520 and £1,800 ; Adams Housing Syndicate (concrete construction), £1,520 and £1,730 ; E. O. C. Howells (Coventry), (concrete construction), £1,580 and £1,880. The tender of Mr. B. Copeland is recommended for acceptance. For the erection of 20 houses at Oakthorpe the following tenders were received :—B. Copeland, £1,287 per pair for type "A" houses and £1,530 7*s.* 6*d.* for type "B" houses ; B. Cole, £1,399 and £1,654 ; Southam, Roones & Aldridge, £1,410 and £1,650 ; T. Lowe & Sons, £1,507 and £1,777 ; G. Hodges & Son, £1,522 and £1,790 ; T. Rowbotham, £1,520 and £1,730 ; Adams Housing Syndicate (coacrete construction), £1,520 and £1,730 ; E. O. C. Howells (concrete construction), £1,580 and £1,880. In this case the tender of Mr. B. Copeland is also recommended for acceptance.

Blaydon.—The Blaydon Urban District Council has accepted the tender of the Victory Concrete Block Co., Ltd., for the erection of 40 houses on the Chopwell site, at £32,800. A total of 200 houses are to be built on this site.

Callington.—The Callington (Cornwall) Urban District Council has provisionally accepted the tender of Mr. C. B. James, of Callington, at £2,179 10*s.*, for the construction of reinforced concrete cattle pens, and other work, at the Callington Cattle Market. Other tenders received were : C. Symons, Liskeard, £2,247, and Dale & James, Leicester, £2,512.

Dublin.—The Dublin Corporation has received the following tenders for the erection of 60 cottages of concrete block construction in the Fairbrothers Fields area (two types of four-room cottages and one type of five-room cottage, all built in pairs). McNally & Co. (Dublin), £77,460 ; L. Minks (Dun Loughaire Co. Dublin), £72,613 ; Richard Gough (Dublin), £70,714 ; J. & W. Beckett, Ltd. (Dublin), £69,237 ; Municipal Workshops (Dublin), £63,197 ; J. & R. Thompson, Ltd. (Dublin), £63,479 ; H. & J. Martin (Dublin), £61,782 ; Building Trades Guild, Ltd. (Dublin), £61,744. The tenders of the Municipal Workshops and the Building Trades Guild, Ltd., are based on a schedule which omits the provision of plant insurance, etc. The whole of the tenders are under consideration.

Glassford.—Glassford Education Authority has accepted the tender of Messrs. J. Bertram, Strathavon, at £1,070 4*s.* 7*d.*, for the construction of the concrete slab walls and concrete floors at the proposed new school.

Grays (Essex).—The Thurrock, Grays and Tilbury Joint Sewerage Board has accepted the tender of Messrs. F. E. Binns & Co., of Croydon, at £89,511, for the construction of about 1,060 yards of concrete sewer tubes and cast-iron sewers of 36 in. diameter, manholes, and other works.

Leeds.—The Leeds Corporation has accepted the tender of Messrs. William Airey & Son, Ltd., for the erection of concrete houses, as follows :—Middleton Estate, 250 houses : Type "A" houses, £665 each ; Type "B" houses, £775 each ; Type "C" houses, £720 each. Cross Gates Estate, 400 houses : Type "A," £650 ; Type "B," £750 ; Type "C," £700.

The Victoria
CONCRETE MIXER

THIS illustration shows one of our concrete distributing plants designed to serve an area of 100 feet radius. The chuteing is divided into two sections, the outer section being balanced. By this means it is possible to deliver the mixed concrete anywhere within this radius, speedily and with a minimum of labour and effort. This distributing plant greatly simplifies the erection of large buildings and engineering works, and renders considerable economics possible.

THE plant illustrated here is now in course of construction to the order of a client.

PARTICULARS of this plant and of the "Victoria" Concrete Mixers to use in conjunction with it will gladly be supplied on request.

STOTHERT & PITT
LIMITED
(MIXER DEPARTMENT)
11, VICTORIA ST., LONDON S.W.1

London (Islington).—The Islington Borough Council has accepted the tender of Johnson's Reinforced Concrete Engineering Co., Ltd., of 1 Basinghall Street, E.C.2, for the supply of reinforcement fabric for the foundations of parts of Seven Sisters Road and Holloway Road, at £287. Other tenders received were: The British Reinforced Concrete Engineering Co., Ltd., Westminster, £339 16*s.* 2*d.*; and Messrs. Hill, Menzies & Co., Ltd., London, £309 5*s.*

Long Ashton.—The Long Ashton Rural District Council has accepted the tender of Messrs. Coles & Son, of Clevedon, Somerset, at £1,056 6*s.*, for repairing and strengthening with reinforced concrete the bridge at Haberfield, Easton-in-Gordano.

Macclesfield.—A revised tender has been received by the Macclesfield Corporation, from Messrs. Sharples & Atherton, for the construction of 26 concrete houses. The prices are £780 each for Type "A" houses and £847 10*s.* for Type "B." houses, and the tender has been sent to the Housing Commissioner for the area.

Middleton.—The Middleton Corporation has received the following tenders for the erection of a concrete culvert over the river Irk. Tender B:—Sir Wm. Arrol, Ltd. (Glasgow), £5,203 9*s.* 3*d.*; D. G. Somervile & Co. (London), £4,190; Pullar & Co., £3,700 3*s.* 1*d.*; Inchley & Co. (Manchester), £6,556; Reinforced Concrete Construction Co., £5,394 (alternative tender, £4,672); R. Holst & Co. (London), £3,828 4*s.* 6*d.*; Peter Lind & Co. (London), £3,164 15*s.* 6*d.*; F. Moehl, Ltd. (London), £8,900; J. H. Bardsley, £4,177 17*s.* 6*d.*; W. H. Worthington, £4,691 10*s.* 4*d.* (alternative tender, £4,410 5*s.* 4*d.*); Varley & Hartley, £4,342 6*s.* 10*d.*; Silwood Construction Co., Ltd., £6,227. The tender of Messrs. Peter Lind & Co. has been accepted.

Oakham.—The Oakham Urban District Council has received the following tenders for the erection of 10 houses in Station Road, Oakham: Higgs & Sons (Oakham), £6,730; Graham-Denny, Ltd. (London), £7,159; J. Hibbitt (Oakham), £7,280; J. Simpson (Oakham), £7,488; "Interloc" Concrete Construction Co. (Leicester), £7,560; A. Tate (Uppingham), £7,990; Clarke & Belton (Stamford), £8,012; B. Cole (Leicester), £8,057; E. J. W. Wilson (Stamford), £8,148; Bowles & Son (Leicester), £8,166. The tender of Messrs. Higgs & Sons has been accepted subject to the approval of the Ministry of Health.

Tredegar.—For the erection of 162 houses, the Tredegar Urban District has recommended that the tender of the United Valleys Building Guild be accepted, at £132,070 12*s.* 6*d.* The next lowest tender was that of the Adam Housing Syndicate, for concrete houses, at £133,640, and other tenders received were: Gay & Co., Ltd., £148,484; and Richard Jones, £162,221.

Upton-on-Severn.—The tender of Messrs. Parker & French, of Great Pulteney Street, London, W.1, has been accepted by the Upton-on-Severn Rural District Council for the construction of a service reservoir, and other incidental works.

TENDERS INVITED.

Bolton-upon-Dearne.—July 11.—Erection of 76 houses, and the construction of the necessary roads and sewers, for the Bolton-upon-Dearne Urban District Council. Specifications, etc., from Messrs. Garside & Pennington, architects, Ropergate, Pontefract.

Gateshead.—July 12. Erection of new telephone exchange, for H.M. Commissioners of Works. Specifications, etc., from H.M. Office of Works, 63 Westgate Road, Newcastle-on-Tyne; Bills of Quantities, etc., from Contracts Branch, H.M. Office of Works, King Charles Street, London, S.W.1. Deposit, one guinea.

Worthing.—July 14. Erection in brick and concrete blocks of 68 houses of various types on the South Farm Road housing site, for the Worthing Corporation. Bills of quantities, etc., from the architect, Mr. S. C. Phillips, Municipal Offices, Worthing. Deposit, two guineas.

Heywood.—July 15. For the erection of 10 houses, for the Heywood Corporation. Plans etc., from Messrs. J. T. Proffit & Sons, architects, Memorial Road, Walkden, near Manchester.

Chapel-en-le-Frith.—July 16. For the construction of a concrete service reservoir, and other work, for the Chapel-en-le-Frith Rural District Council. Specifications, etc., from Messrs. Brady & Partington, engineers to the Council, Town Hall, Chapel-en-le-Frith.

Bombay.—July 26. The date for the receipt of tenders for the construction of 105 miles of steel and reinforced concrete pipe-lines in connection with the Bombay water supply, for the Bombay Corporation, has been extended from May 31 to July 26. Specifications, etc., from Messrs. Taylor & Sons, Consulting Engineers, 36 Victoria Street, Westminster, S.W.1. Deposit, £100.

NEW METHODS AND MATERIALS.

The following have been approved by the Ministry of Health:—

Christiani & Neilsen, 25 Victoria Street, Westminster, S.W.1.—"*Sano*" *system of construction.*—This is a system of timber construction in which the timber is treated with a preservative and the spaces between filled in with concrete. The external face is covered with sawn laths having a backing of bituminous sheeting and finished with cement roughcast. The internal face is finished with laths and plaster.

The Express Builders and Supplies Co., Ltd., 17 Ironmonger Lane, London, E.C.—A system of building a cavity wall with concrete slabs and bonding blocks having a vertical central cavity. The bonding blocks are used as headers alternating with the slabs in every course. Special corner blocks are designed, together with reveal blocks for door and window openings.

R. L. Bendall, 40 Richmond Wood Road, Bournemouth.—*The Bendall Walling System.*—The Ministry of Health has now sanctioned that in the construction of houses on this system the walling may be formed of concrete composed of eight parts of aggregate and sand combined to one part of cement.

The Ferro-Concrete Roof Plate Co., Govett Avenue, Shepperton-on-Thames.—This is a system of constructing the roofs and walls of one-story buildings with reinforced concrete plates fixed to timber framing. The roof-covering plates are formed with longitudinal and horizontal cross-ribs, with a thin sheet of concrete between forming the body of the plate. The longitudinal edges are bolted together, the joints being filled with plastic material and covered with an independent concrete capping. The horizontal joints are lapped and bolted together, and are supported on a wood or steel purlin.

The walls are formed in a similar manner to the roof, in long slabs the full height of the story, bolted together, and secured to wood framing. The corners are stiffened by being filled in solid with concrete. The structure is set on a concrete plinth course above the ground level.

TRADE NOTES.

Messrs. Millars' Timber and Trading Co., Ltd., Pinner's Hall, Old Broad Street, E.C.2, have opened a depot in Kirtling Street, Battersea, for the machinery which they manufacture or for which they are the agents in this country.

On June 14 and 15 a large number of visitors were invited to inspect the collection, which is extensive and interesting.

Of these machines, perhaps the best known is the Jaeger Mixer, manufactured by the Jaeger Machine Company, Columbus, Ohio. This is a batch mixer of the tilting type and made in various sizes, to be loaded by hand or with power. This mixer is also arranged as part of a street paver, being fitted with a boom and bucket.

Millar's Stone Crusher of the jaw-crusher type is a light but strong machine made for crushing quartz, ores, road metal, limestone, clinker, etc., and is supplied with a steel plate screen or elevator.

Another useful machine is the Haiss " Bag Loader " made by the George Haiss Manufacturing Company, New York City. To these machines grading screens are attached and two bags can be loaded at a time. The loader is also furnished with an anti-freezing device. The working cost (not including wages) is said to be ¾d. to 1d. per ton.

Other machines exhibited were :—Millars' " Schramm " portable air compressor, the Clark Tructractor, Acron Wheelbarrows, Spraco pneumatic painting equipments, and various pumps.

NEW COMPANIES REGISTERED.

Duvol, Ltd. (174,770).—Registered May 19. 390 Green Lanes, London, N.4. Manufacturers of building blocks, slabs and bricks. Nominal capital, £2,500, in 2,500 £1 shares. Directors : T. D. Durant, 48 Endymion Road, London, N.4 ; F. G. Voller, 4 Seaforth Gardens, London, N. ; and Ethel M. C. Kemp 48, Endymion Road, London, N.4. Qualification of Directors, £200 ; remuneration, £10 each.

Improved Building Construction Co., Ltd. (174,884).—Registered May 25. Builders and contractors. Nominal capital, £5,000 in 5,000 £1 shares. Directors to be appointed by subscribers. Qualification of directors, 1 share ; remuneration to be voted. Subscribers : M. England, 24 Norsham Street, London, S.E.13, and D. Clarke, 26 Regent Square, London, W.C.1.

Blocks, Ltd. (174,948).—Registered May 30. Vicarage Lane, South Bersted, Bognor, Sussex. Builders and contractors and manufacturers of artificial stone and concrete blocks. Nominal capital £800, in 160 £5 shares. Directors : R. B. Collins, Parsonage Farm, Barkham, Sussex ; L. L. Hutcheson, 2 Inverness Gardens, London, W.8 ; S. H. Gunston, Seaway Cottage, Middleton, Sussex ; and G. S. Robertson, Southdowns, Middlesex. Qualification of directors, five shares ; remuneration to be voted.

British Fibro Asbestos Products, Ltd. (175,105), Manor Road, Erith. Registered June 8. Dealers in and manufacturers of asbestos, compressed jointing, etc. Nominal capital, £30,000, in 30,000 £1 shares. Directors : F. Bendle, 1 Queen's-gate, London, S.W.7 ; G. H. Buxton, The Elms, Erith ; D. K. Smith, 52 Westcombe Park Road, London, S.E. Remuneration of directors to be voted by Company.

RECENT PATENT APPLICATIONS

148,767.—J. Stone : Method of casting concrete in water.

148,825.—W. Fuchs : Device for the mechanical discharge of lime-burning kilns and cement kilns.

162,007.—H. C. Badder : Method of decorating or covering concrete and other walls, etc.

162,032.—E. B. Hack and G. M. Burt : Concrete breaking machine.

162,033.—J. Cuthbertson : Insulating sheets or slabs.

162,098.—B. Bradley : Reinforced concrete pipes.

162,139.—L. Anderson : Building blocks.

162,143.—J. W. Boyd : Manufacture of impervious building blocks.

162,149.—G. R. Meyercord : Jointing vitreous slabs.

162,472.—W. J. Mellersh-Jackson (Insley Manufacturing Co.) : Apparatus for handling concrete.

162,580.—J. C. Beswarick : Wall ties.

162,610.—J. F. Matthews : Concrete fences.

162,726.—R. Ashworth : Moulded concrete units for building construction.

162,742.—W. R. Hume : Centrifugal moulds for concrete products.

162,784.—T. & B. Moss and T. & F. H. Knowles : Building construction.

162,845.—J. G. D. Armstrong : Concrete wall construction with large pre-cast blocks erected by machinery.

162,859.—J. H. Punchard : Building blocks.

162,866.—H. Willdig & G. W. Wood : Process for finishing concrete surfaces.

162,867.—H. Willdig & J. W. Wood ; method of moulding concrete.

162,950.—J. Ryan : Building blocks and slabs.

163,003.—R. Patterson : Concrete buildings.

CONCRETE AND CONSTRUCTIONAL ENGINEERING

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EDITORIAL NOTES.

AN OFFICIAL INVESTIGATION INTO THE STATE HIGHWAY SYSTEM OF CALIFORNIA.

THE recently published report of the U.S. Bureau of Public Roads resulting from a study of the California State Highway system presents many interesting features and contains many illuminating statements of fact.

The State's old standard for this type of road was a width of 15 ft. with 3 ft. earth shoulders, concrete proportion 1 : 2½ : 5, 4 in. thick and the surface either covered with ⅜ in. of asphaltic oil and pebbles or left plain. This standard, which has now been abandoned in favour of a thickness of 5 in. of reinforced concrete, was adopted with a view to providing the State with as great a mileage as possible of serviceable highways, and on this point the report says: "It cannot be said in 1920, in the light of the fact that the great usefulness of the highway system is now proved, that the State would have realised its usefulness and provided funds in equal volume had not the system been extended as rapidly as it was, and at some sacrifice of either temporary or ultimate durability to increased mileage."

For purposes of comparison of their present condition the roads are classified in the report into six grades, A to F, inclusive, A, B and C being regarded as good or more than good, D fair, E poor, and F bad, that is to say badly broken and with disintegrated portions. In view of the fact that in the United States, according to the *Engineering News Record*, the total motor vehicle traffic in 1920 was six times that in 1912, and that the total truck registration is approximately six times that of 1915, the figures given in the report relating to the present condition of these lightly constructed roads are rather remarkable. Of the 1,262 miles of concrete pavement in this State 87·5 per cent. were found to be in classes A, B and C and 12·5 per cent. in classes D, E and F. Of those in the three poorer classes, 70 per cent. were laid on clay or adobe soils, but it is pointed out that "a large mileage of the same thin pavement and on adverse soil still remains of classes A, B and C."

The table showing all classified concrete pavement built by the State from 1913 to 1920 is very informing, and clearly demonstrates the result of experience, and consequently improvement in method in this form of road-making. In 1913 the mileage laid was 20·46, and of these, to-day, 38·8 per cent. are in classes D, E and F, and 61·2 in classes A, B and C. In 1920 77·41 miles were laid, and of these, 3·5 only were classed as D, E or F, and 96·5 as A, B or C. The greatest mileage was laid in 1915, the total being 350·79, and the present classification for roads of that year is, A, B and C, 89·4 per cent., and D, E and F, 10·6 per cent.

So much for figures. What is, perhaps, of greater interest are the conclusions at which the Bureau arrived, and the chief of these are embodied in the following extracts from the report :

"There is nothing presented by the entire California study that indicates that concrete is not a successful pavement."

"The 4-in. 15-ft. concrete pavement was continued beyond the point of success on adverse soils and more time will be needed to develop a type of construction certain of success on such soils. The operations have produced a large mileage of very serviceable road, and from an economic standpoint are conspicuously successful and of continuing benefit to the State."

"This concrete pavement is the thinnest that has been laid in any State, and would have been rejected in any State subject to winter frosts. It is in general 3 ft. too narrow. The original mix of 1 : 2½ : 5 was leaner than that extensively used in other States, and the present mix of 1 : 2 : 4 is not as rich as usual in several States, but it is believed to be adequate for the traffic. California was the pioneer State in adopting concrete for the State highway system."

"The 4-in. plain concrete of lean mix has proved in places very durable. There are 580 (distributed) miles built prior to 1917 that are of classes A and B. Under adverse conditions, particularly of soil, it is, however, evident that a pavement of such thinness has a very low safety factor and is inadequate."

"The original concrete pavement design in short now has little or no factor of safety, and under unfavourable conditions has not withstood the internal stresses produced by traffic flexure and variations in temperature and subsoil moisture. It is doubtful if such a safety factor can be introduced without considerably increasing the mass of concrete. It appears that under adverse soil conditions there is considerable flexure with traffic."

"There are sufficient typical failures to show that in future only designs of increased strength and adapted to resist such failure should be used. There will be necessary every precaution to prevent failure on adverse subsoils of adobe, clay adobe or similar soils. . . . Such a design will require the reinforcement now provided by the commission [42 lb. of ½-in. and ⅜-in. steel rods in the centre plane per 100 sq. ft.], and a more massive type of concrete not less than 6 in. in average depth, and some adequate corrective treatment of subgrade, and possibly a form of 'mulching' of shoulders to prevent evaporation. A flat subgrade is desirable and less crown." [It is suggested that the crown of 2¾ in. in the present 15 ft. standard design be reduced to 1¾ in.]

"The continued use of the ⅜-in. soil top is not justified by past experience, and concrete should not be laid as a base, but as a wearing surface."

In view of the fact that the United States possesses, to-day, something like 12,000 miles of concrete roadway, we have to admit, which we do most readily, that that country has been far ahead of our own in enterprise ; but, in reading through this report, we could not but be struck with the number of the Bureau's conclusions which coincide with the experience of road engineers on this side. In the first place, practically every concrete road in this country is reinforced. The position of the reinforcement is a matter for debate and depends upon the view taken by the individual engineer as to its function. Again, the general practice in this country is to make the concrete of a depth of 6 in. ; and, further, many road engineers, who have had experience in concrete, are coming to the conclusion that a bituminous surface is neither necessary nor desirable.

Then, again, with regard to the proportions adopted, the report points out that the original mix of 1 : 2½ : 5 was leaner than that extensively used in other States, and although it is stated that many miles of roads laid with this quality concrete are still in classes A and B, the inference is that a richer mix is desirable. Speaking generally, our own concrete roads are laid in two courses: 1 : 6 for the lower course, and 1 : 3 with a fine aggregate for the wearing course, and this method seems to answer quite satisfactorily.

Where the subgrade is bad, certain of our road engineers have adopted the practice of increasing the thickness of the concrete and using double reinforcement, the lower layer to take the tensional stresses, and the upper layer to take time temperature stresses and so prevent cracks.

We attach great importance to this report, since it is the report of a Government department and, therefore, impartial, and because it is critical and thorough.

COLLAPSE OF THE GOVERNMENT HOUSING PROGRAMME.

WHATEVER may have been our opinion as to the economic soundness of the Government's Housing Scheme, so soon as the Housing and Town Planning, etc., Act, 1919, became law, we gave all the support we could to further the Housing Campaign. And we think that, the principle contained in the Act having been once accepted by Parliament, the Government should have pursued this course and carried through that which they had undertaken, rather than suddenly to abandon the entire project just at the moment when prices are falling, and when the prospects of at least partial success are most hopeful.

It may be perhaps interesting briefly to trace the development of the scheme. Already before the end of the war the Government were making preparations for a housing programme, which was to be begun as soon after the cessation of hostilities as possible. With that end in view a committee, under the Chairmanship of Sir Tudor Walters, was appointed to enquire into the whole matter. In October, 1918, an extremely valuable report was issued by this committee, most of the recommendations of which were embodied in the 1919 Act or in the regulations arising therefrom. In the early part of 1919, shortly before the passing of the Act, eleven (since increased to twelve) regional offices were opened in different centres to assist in the administration of the Act and to help local authorities. A Commissioner was appointed in charge of these offices and a staff of technical officers was engaged to help him. At headquarters the services of a staff of experts, under Mr. Raymond Unwin, were obtained. All were enthusiastic for the work, and for the high ideals and standards which the Ministry of Health (then the Local Government Board) professed. Manuals were issued by the Ministry, many of them full of excellent advice, and inculcating ideals in estate development which were new to many local authorities. Back projections were to be a thing of the past, aspect was to be considered and overcrowding forbidden. Monotonous terraces of desolating ugliness and insanitary dwellings were not to be eligible for State Aid. These were indeed high standards. And never was there a more propitious moment for putting them into practice.

At first there were innumerable difficulties and obstacles to be overcome. There was a shortage of labour and materials, some local authorities were sceptical as to the Government's good faith in stating that their liabilities would be limited to a rate not exceeding one penny in the pound. The material shortage was partly overcome by the D.B.M.S., and partly by the use of concrete and of substitute materials. The use of concrete, furthermore, lessened the demand for skilled labour on many jobs. And by dint of hard work, both on the part of the Ministry and the Press, the enthusiasm of municipal bodies was thoroughly aroused. Then came the difficulty of obtaining sufficient capital to finance the schemes, only those authorities with a rateable value of less than £200,000 being allowed to borrow from the Public Works Loan Commissioners. However, the Housing Bonds Campaign was launched, and here, too, partly owing to the good will and publicity given to the matter by the Press, most municipalities were able to raise sufficient money to meet their immediate needs.

During the early spring of last year enormous efforts were made by the Ministry of Health to increase the number of contracts of local authorities, and as a result of this pressure the number of houses contracted for increased, between the end of December, 1919 and the end of March, 1921, from 15,987 to 85,265. However, prices continued to rise and reached their maximum about November last year. About this time the Government began to feel anxious, and decided not to pass tenders at these high figures. The decision was a wise one and prices began to fall. It was naturally assumed, however, that advantage would be taken of the lower prices and the fine weather energetically to push forward the erection of houses during this summer and autumn. The time was propitious, the great machine had at last been set going, after infinite labour and expense. Prices were falling, building labour was more settled, enthusiasm had been aroused, and materials had been accumulated. But this, however, was just the moment that the Government chose to wind up, and orders were sent out that nine out of the twelve regional offices were to close on September 30, and about 150 members of the technical staff are to be dismissed.

Let us consider the economic result of this decision. We find that thousands of acres of land have been acquired all over the country by local authorities for houses that will now never be erected (at any rate by local authorities), that roads have been constructed and sewered, creating miles of frontage that may perhaps never be used. After all the houses now contracted for are built, the Government will have on their hands a surplus of nearly 400 million bricks, of which they cannot dispose ; most of them lying in the brickmakers' yards, and so congesting them that the makers are claiming for storage. Vast stores of other materials have also to be disposed of. Wherever possible existing contracts are being cancelled, and, in some instances, houses which have actually been begun are to be abandoned. If this policy be pursued, contractors all over the country will be suing local authorities for breach of contract. We understand that in some places local authorities are actually paying contractors not to build houses. Meanwhile, out of an estimated need of 500,000 houses, work has started on only 111,893. Work under parts 1 and 2 of the Act which deal with demolitions and slum areas has as yet not been begun, and £200,000 which has been promised as an annual Government contribution, will not afford much relief when spread over the whole country. London alone could absorb that amount. The effect on the building trade of this *débâcle* will be very serious, since housing forms at the moment the chief activity of the industry.

In our opinion, this is the story of a wasted opportunity.

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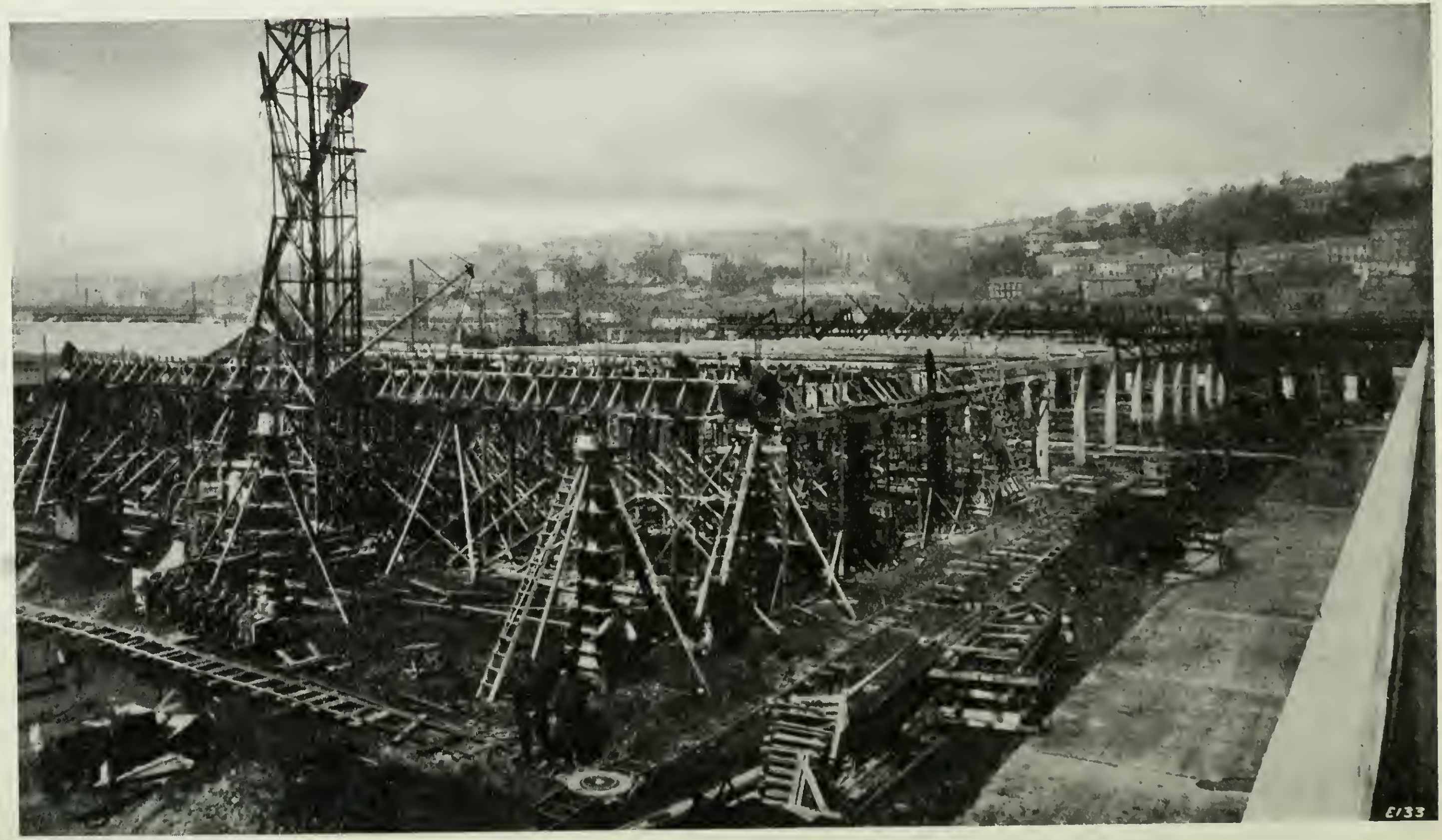
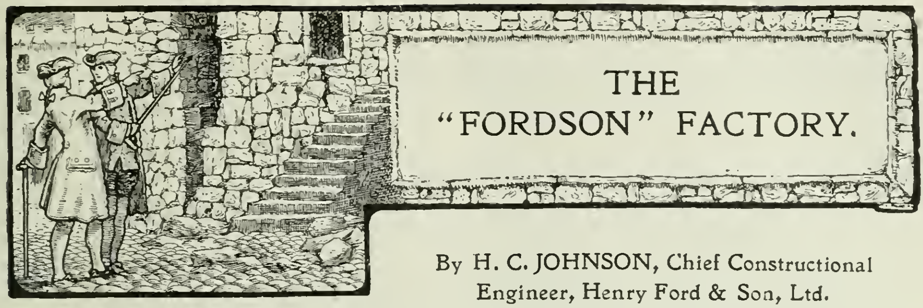


Cork Factory, H. Ford & Son, Ltd., Machine Shop Extension. Shows various Stages of Construction.
(*For description, see page* 491.)



THE "FORDSON" FACTORY.

By H. C. JOHNSON, Chief Constructional
Engineer, Henry Ford & Son, Ltd.

II. PARTICULARS OF CONSTRUCTION METHODS AND PLANT.

In our January issue we published an article by Mr. Johnson generally describing this building, but the construction method and the plant used were of particular interest, and in the following article these are described in fuller detail than was possible before.—ED.

1. *Reinforced Concrete Slabs, Beams, Girders, Trusses and Columns in the Original Machine Shop.*

This building is symmetrical about its longitudinal centre line and, with the exception of end bays, all bays are alike, but several outstanding items being unusual might be of interest. See *Fig.* 1 for plan and section.

Slabs are 3 in. thick and 6 " t " (i.e., 6 × 3 in.) on each side of beam splay was used in computing the compressive area of beams. The tension steel was placed $\frac{1}{2}$ in. from bottom of slab at centre of span and alternate bars were bent up over supports and supported by specially made bar raisers and clips (patent applied for) of shape and action shown by *Fig.* 2. To form these a special machine (smithy made on the job) was used and they were punched out of $1\frac{3}{4}$ wide by about 14 gauge metal strip, the shape being such that no metal was wasted.

Beams are all 33 ft. span, thus giving only one row of columns per half building. Special note might be taken of the cut-away portion of slab at light wells which started at such a point from the centre of span that the compressive stresses did not require the slab to assist. All beams have four 3-ft. long steel inserts for bolting up shafting and three $1\frac{1}{2}$-in. diam. tubes near underside of slab for electric conduit, etc.

Girders, all 22 ft. span, are practically the same in section as the beams, excepting that they are 2 in. wider and 2 in. deeper and are provided with two $1\frac{1}{2}$-in. tubes for electric conduit.

Trusses (concrete)—being those carrying centre loads from interior beams and also the crane rail—are designed with diagonals in compression instead of in tension, because the method gave a greater vertical shear area at supports with less obstruction of light.

Their design naturally involved the suspension of the interior beam ends by $1\frac{1}{8}$-in. rods, but with a good hook at their upper ends and a fairly long anchorage in the depth of the top member of the truss no difficulty was encountered.

Columns are of three sections :—

(1) Exterior with groove for steel sash with simple vertical bar and hoop reinforcement.

(2) Ordinary interior—simple verticals and hoops.

(3) Crane way, this is of heavy section to take steel truss posts, crane and roof wind loads, and is also of verticals and hoops.

Construction joints. These were all arranged so that they passed through mid-span of slabs and diagonally across columns ; at no point did they cross beams or girders within the span. This called for a zig-zag course as sketched on *Fig.* 1. Reinforcement of beams, etc., is as per *Fig.* 3.

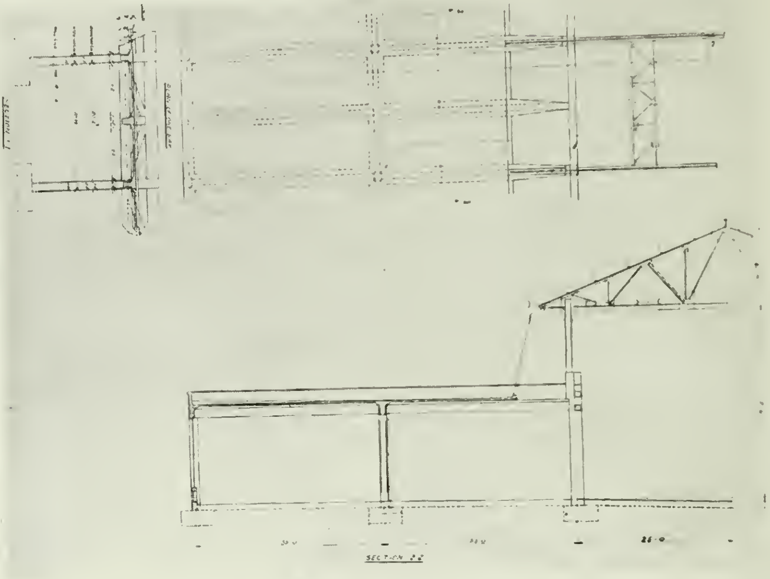


Fig. 1. Original Machine Shop. Plan and Part Sections.

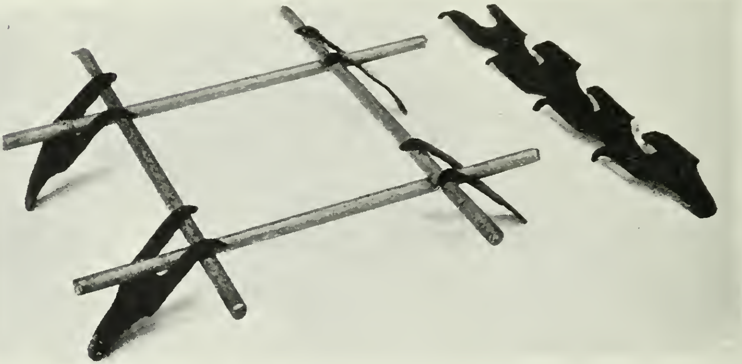


Fig. 2. Combined Bar Raisers and Clips (Pat. pending).

2. *Formwork* for slabs, beams, girders, trusses and columns was figured for sizes, etc., just as carefully as the reinforced-concrete portion ; the writer thoroughly believes in this where the formwork has to be used more than once, and even then more than the rule-of-thumb design is needed, since 25 per cent. to 50 per cent. of the total cost of the structure goes into once-used formwork for first-class work, but this reduces almost in proportion to the number of times it is used. Too little attention is often paid in these countries to this important

and expensive part of the work, whereas in America it receives very close attention not only in design in the office, but on the job, to see that it is not damaged.

[The general arrangement of forms employed in these buildings is well illustrated in an article by the writer in the January, 1913, issue of CONCRETE AND CONSTRUCTIONAL ENGINEERING entitled " Floor and Column Forms for a Typical all Reinforced-Concrete Building."]

Special notice might be taken of the column forms which may, to some, appear elaborate, but which are really very simple. The " clamps " form the cleats for the sheeting, but extend beyond this sheeting to allow for wedging up against blocks nailed on at their ends. To release the forms, all wedges are knocked out, two clearance pieces (one at bottom on each side of column) are knocked away, letting sides drop, when they can be withdrawn, wedged together again and re-erected. No nailing of any sort is required or allowed once the forms are made.

Column forms were erected on wooden " boxes " 4 in. deep, laid on the pile caps but with their top edges absolutely level 8 in. below finished floor line and then nearly filled with strong cement mortar to keep them in place. These were placed with level and theodolite by the " setting out " engineer.

Girder, beam and slab forms were made in interdependent units. The vertical portions of beam sides were in one piece 31 ft. 9 in. long, 1 × 4 in. sheeting horizontal, 6 in. × 1½ in. cleats vertical and outside these was bottled a 3 in. × 3 in. × ¼ in. angle as stiffener and also bearer for slab form joists. Beam bottoms were supported on 2 in. × 1 in. strips nailed to beam sides. The girder bottoms were quite different, being bridges (called " girder bridges ") with span from column side to column side, and on these the beam sides were carried and adjusted, the girder sides fitting between them. A special form of " key " allowed easy adjustment between beam and girder sides and also column sides and facilitated removal. (The article in January, 1913, issue shows this very clearly.)

Slab (and partly beam) forms were made in easily handled sections, four per 33 ft., and contained the splay section of beams and girders, sheeting being 1 in. T. & G. and joists 4 in. × 2 in.

Posts of 6 in. diameter rough spars with 4 in. × 4 in. crossheads adjusted by hardwood folding wedges at bottom rested on a 12 in. × 6 in. × 36 in. bearer spreading its load in turn to three 9-in. × 3 in. × 36 in. sleepers.

A camber of 1½ in. was given to all beams, one-half of which was intended to be permanent, the other was calculated as actual compression of soil and timbering settlement, and on the whole this proved to be the case. There is no permanent camber to girders, but a ⅜ in. wedge-up for settlement is made.

Truss forms were fully detailed to the last dimension and so made that quick erection and removal without nailing was possible. Four sets were made for the thirty-two trusses, so that on an average they were used eight times, and in the case of one or two sets eleven times, and are still available for extension.

Of the general formwork five and a half sets were made, thus giving an average of six times use.

All faces in contact with the concrete were creosoted before use and before the fourth, seventh and tenth occasion of erecting. This is the first structure on which the writer has used creosote, but it protected the surface so well—keeping it hard and preventing " ragging "—that soft soap, oil or limewash are things of the past. The surface of the concrete just after removal of forms was more or less blackened by the creosote, but this was always either cement-burnt or rain-washed away within a few days and in no way affected white water paint applied later or oil paint applied recently.

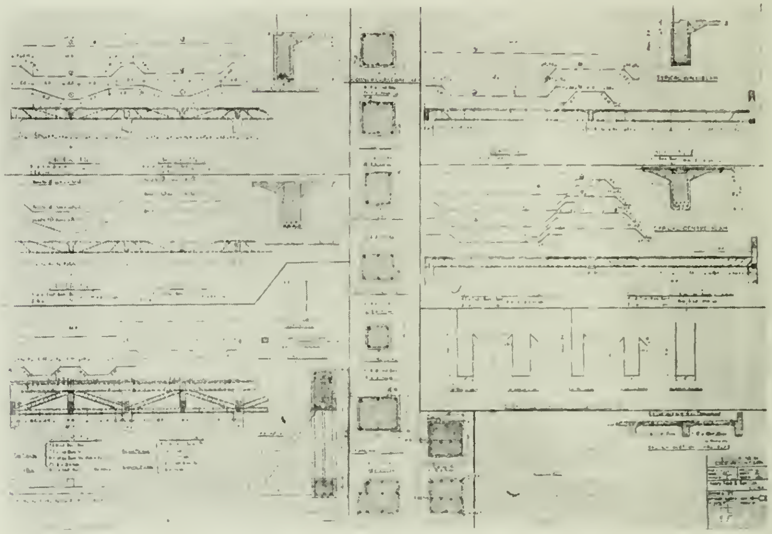


Fig. 3. Details of Beam Reinforcement, etc.

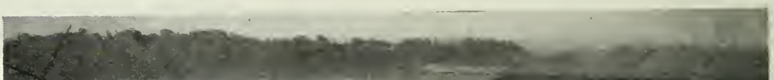


Fig. 4. Foundry Roof looking South-west (shows simple Roof Trusses).

2. *Reinforced Concrete Members of Machine Shop Extension, also low portion of Foundry Extension.*

These structures are of the saw-tooth roof variety and naturally differ greatly from the original shop just described, since there is no slab, but only beams and girders. The spans in the machine shop are still 33 ft. and 22 ft., with beams of T and other members of rectangular cross-section and provided with slots instead of inserts for shafting. These slots pierce the members and are 10 in. and 20 in. long by 1½ in. wide and they give far greater rigidity to shafting members. *Figs.* 4 and Frontispiece show general arrangement and formwork.

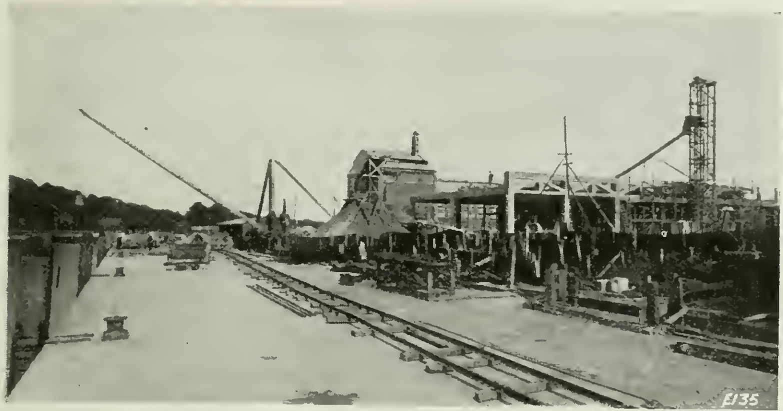


FIG. 5. SHOWING METHOD OF HANDLING THE CONCRETE.

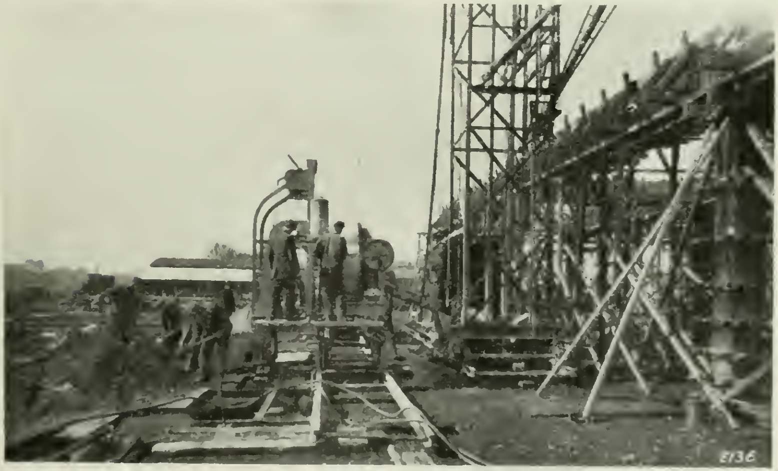


FIG. 6. SHOWING METHOD OF HANDLING THE CONCRETE.

Here again formwork was closely studied and figured, but a very different arrangement made in beam and girder form members, since there were no slab joists to take side pressure.

It will be noticed that alternate bays in the foundry were without girders, resulting in a considerable saving. This method gives what in effect may be considered a set of 22 ft. wide strips of building, each separated by 22 ft., but all covered with saw-tooth roofing.

3. *Concreting Methods, etc.*

Owing to difficulties of purchase and shipment during the earlier part of the work, which was in the war period, much of the plant and apparatus was either made or improvised, but this only gave added interest to the work. Some of the items in the following describe these. The aggregates used were—

(*a*) River gravel (supplied by the Harbour Board in early stages of the work), or

(*b*) Bank gravel (obtainable in unlimited quantities by water from pit seven miles down river Lee) and

(*c*) Crushed limestone (also easily obtainable) and

(*d*) Bank sand (also easily obtainable).

These were brought alongside the wharf and taken ashore by derrick crane, the gravel being discharged directly into a large bin over which was a screen for excluding the larger particles. This bin was so placed that its gate discharged directly into the hopper of the mixer, from which Jubilee track and wagons took the mixed concrete direct to the elevating tower. This arrangement of handling is shown in *Fig.* 5.

The mixers in use were a ½-yard Ransome, one with and one without elevating hopper. They worked well throughout up to a maximum of 18 cubic yards per hour each.

The tower and chute outfit is "home-made," including wheeled undercarriage, which made it a travelling unit. The height of 62 ft. gave a reach of chute of 70 ft. The hoist bucket was specially arranged to fall backwards and toward the wagons for charging after it reached the bottom of tower, thus avoiding the usual hole in the ground, which would have prevented the moving of the tower. The usual friction hoist electrically driven and of one-ton capacity was used, the operating lever of which was lifted on to a trigger for hoisting and by means of a stud on the hauling rope this trigger was withdrawn when the bucket reached the discharge point at top of chute. (See *Figs.* 5 and 6.)

Tower particulars are as follows :—

Height 62 ft.

Material 3 in. × 3 in. × ¼ in. verticals and 2½ in. × 2½ in. × ¼ in. horizontals and diagonals.

Undercarriage, 6 double flange wheels 12 in. diameter, with 3 in. axles and 8 in. × 6 in. joist frame.

Joints all single bolted ¾ in. bolts.

Hoisting rope, steel, ⅝ in. diameter.

Guy ropes, steel, ½ in. diameter.

Back rope from top of tower to heavy stakes in ground and to take pull of chutes, etc., was ¾ in. diameter steel with 1½-ton chain block for adjustment during travel of tower to new position. The tower was made to move itself by releasing hoisting rope from drum and using a temporary rope run to a timber cross-head placed against end of rails (60 lb.) on which the carriage wheels ran. During this operation all guy ropes were left slack but back rope adjusted, though kept tight, as required. The moves of 44 ft. each per shift were easily made in about one hour.

Chute and jib particulars :—

Chute angle approximately 27 degrees from horizontal. Material 18 gauge black iron bent U-shape with 2 in. × 2 in. × ¼ in. angles on inner edges and turned in and strapped across tops every 5 ft. with 2 in. × $\frac{1}{4}$ in. flats, the width 10 in., depth 7 in.

The extension chute (to turn through 360 degrees) was of the same material, counter-balanced with a light frame as shown.

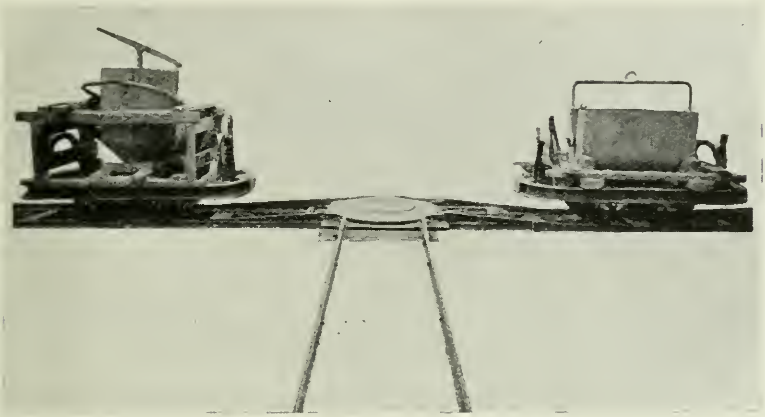


Fig. 7. Showing Jubilee Track Turntable Approach Lines.

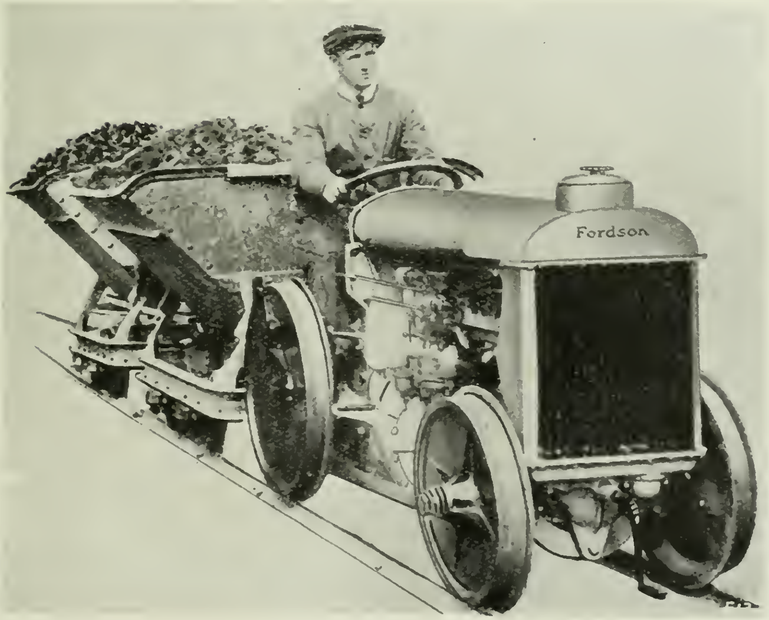


Fig. 8 A Fordson Tractor.

The *jib* is of $2\frac{1}{2}$ in. × $2\frac{1}{2}$ in. × $\frac{1}{4}$ in. angle and very lightly braced with 2 in. × $\frac{1}{4}$ in. flats and $\frac{3}{4}$ in. rods.

[The writer will supply further particulars direct to any one interested.]

A cost comparison between the derrick which was used for the first three bays and the tower is most interesting.

Cost and time per bay of 22 ft. × 66 ft.—quantity of concrete 42 cubic yards.

Derrick—8½ hours with a labour cost of £11 13*s*.

Tower—3¼ hours with a labour cost of £3 7*s*

Of course the men were more used to the work when this figure was obtained with the tower, but, on the other hand, the concrete was being placed over 300 ft. from the mixer, whereas the crane lifted it direct from mixer on to the roof within 50 ft. of its final position.

More interesting than this, to the man actually on the work, was the entire absence of confusion with the tower, whereas the derrick arrangement called for a *hopper* into which the concrete was poured, and from which it was run in *wheelbarrows* on *plank runways* resting on *two leg-stools*. Naturally, when a section had been nearly poured, the stools and runways had to be removed; then it was comparative confusion directing the men this way or that to get a circuitous route to avoid the outgoing line hindering the returning line of barrows.

Objection might be taken by many to having concrete wet enough to flow down such a slope, but if the following will help to convince them then we will be able to produce concrete structures quicker and cheaper than at present.

(1) Cost of placing is greatly reduced.

(2) Possibility of " pockets " in the structure is avoided.

(3) The steel is much better protected.

(4) A properly proportioned and denser concrete.

(5) 2,600 to 3,000 lb. per sq. inch for 20 per cent. (i.e., average 1 : 2 : 4) concrete at twenty-eight days possible.

(6) A weight of 150 to 156 lb. per cubic foot and therefore a very dense concrete obtainable.

(7) A steady and known amount of concrete placed per hour without confusion.

(8) Fewer items in plant—avoiding barrows, runs, etc.

(9) The whole outfit stands away from, and free of, the formwork, steel placing, etc., and is quickly and effectually cleaned by hoisting and discharging one bucket of water through the chutes.

All column forms were filled from the top even in the case of spiral reinforced columns 20 ft. high and only 15 in. diameter and with the best possible results.

Figs. 7 and 8 show some items of possible interest being made or added to by the job blacksmiths. They are—

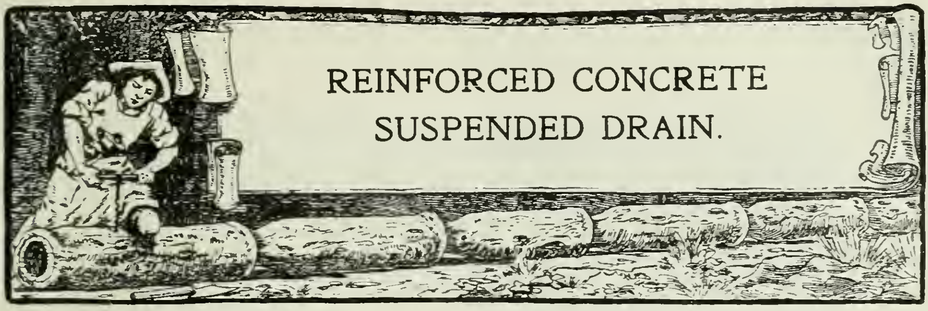
(*a*) Jubilee track turntable approach inclines to allow the wagons to rise from a continuous rail under the turntable, then turn and pass off at right angles. This allows of the turntable and branch track being shifted along the main continuous track without disjointing it for each new turntable position.

(*b*) Bottom pouring buckets for concrete for direct discharge into column forms and similar small spaces.

(*c*) Side pouring buckets for concrete for direct discharge into forms of rectangular beams.

(*d*) " Fordson " tractor converted into a loco for 24 in. gauge Jubilee track.

In conclusion, the writer wishes to name his assistants, Messrs. W. W. Doran, T. C. Courtney, and O. J. Turney, who, with others, are graduates of the Cork University College, and to whom the success of the construction is greatly due.



REINFORCED CONCRETE SUSPENDED DRAIN.

By W. L. SCOTT, A.M.Inst.C.E.

A very interesting example showing the adaptability of reinforced concrete is demonstrated by the recent construction of a suspended drain in this material, some 800 ft. in length.

The work was carried out for Messrs. The Empire Paper Mills, Ltd., at their works at Greenhithe, Kent. The mills are situated on the southern bank of the river Thames, and the foundation is such that the existing buildings have to be carried wholly on piles, the bearing capacity of the ground being insufficient even for the lightest of working loads.

Since this drain was required to pass under the ground floor of the buildings, for the greater part of its length, the latter difficulty was serious from a designing point of view. The only practical means of supporting this drain was to hang it to the underside of the floors, which are constructed of rolled steel joists embedded in concrete. Certain parts of this floor are subject to some vibration from machinery overhead, and careful consideration had to be given to this aspect of the problem, before deciding on suspension as a means of carrying the drain.

Another difficulty presented was the very limited headroom, which was insufficient to permit a man to stand upright, and also the nature of the soil, which is composed of soft material some feet thick, containing a large percentage of wood pulp and moisture. These objections, together with the fact that artificial light was necessary at all times, rendered *in situ* construction so difficult as to be impracticable. It was therefore decided to construct this drain in pre-cast lengths, and to connect these lengths by means of pre-cast "collars," which were in turn slung to the underside of the steel floor bearers. The exact arrangement employed may be seen from the accompanying sketch (*Fig.* 3).

The sections were cast in 4-ft. lengths, and made U-shaped. They were 2 in. thick, and reinforced with a single mesh of steel composed of plain round-section rods laid in both directions, and wired at their intersections. Each length as cast was stiffened at the top by a central reinforced concrete strut, 2 in. by 3 in.

When the sections and "collars" were fixed in position, the joints were run in with rich concrete grout, and the attachment to the underside of the floor concreted up in position. A detail of the latter attachment is shown, and the illustration (*Fig.* 2) shows a short length of drain in position, which will give the reader a very good idea of the difficult nature of the work.

The design of this drain was placed in the hands of Messrs. The Considère

Construction Company, Ltd., of Westminster, and the success of the drain, both during the tests and in practice subsequently, proves that the somewhat novel decision to carry this drain by suspension was warranted.

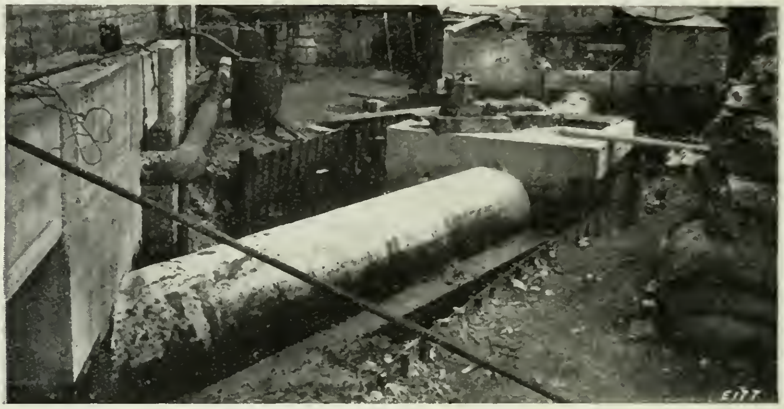


Fig. 1. Showing External Drain in Position.

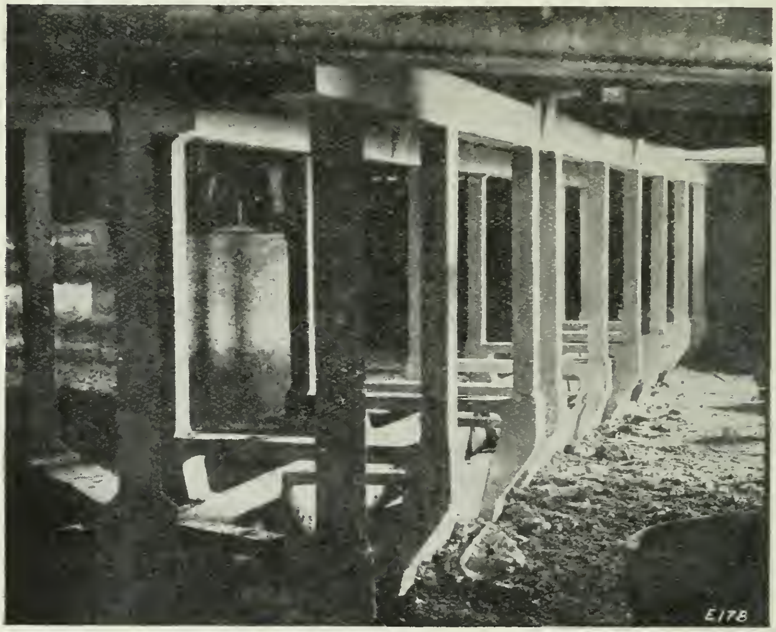


Fig. 2. Portion of Internal Drain, showing Method of Suspension.

The concrete for the work was composed of one part of cement to one part of sand and two parts of larger aggregate. The aggregate stones were uniformly graded and screened so as to pass a ½ in. square mesh, and to be entirely retained on a ¼ in. square mesh.

The whole of the work was carried out on the site, and the surface of the pre-cast concrete while "green" was dusted with neat cement well rubbed into the pores with rags, and the excess removed. As soon as possible after moulding, the surfaces were coated with one part of sodium silicate to five parts of water, this being applied with a brush. Four coats were applied thus, at intervals of between six and twenty hours. All the joints between the pre-cast pieces were similarly treated, and the whole of the concrete was kept damp for at least a fortnight, in order to prevent shrinkage.

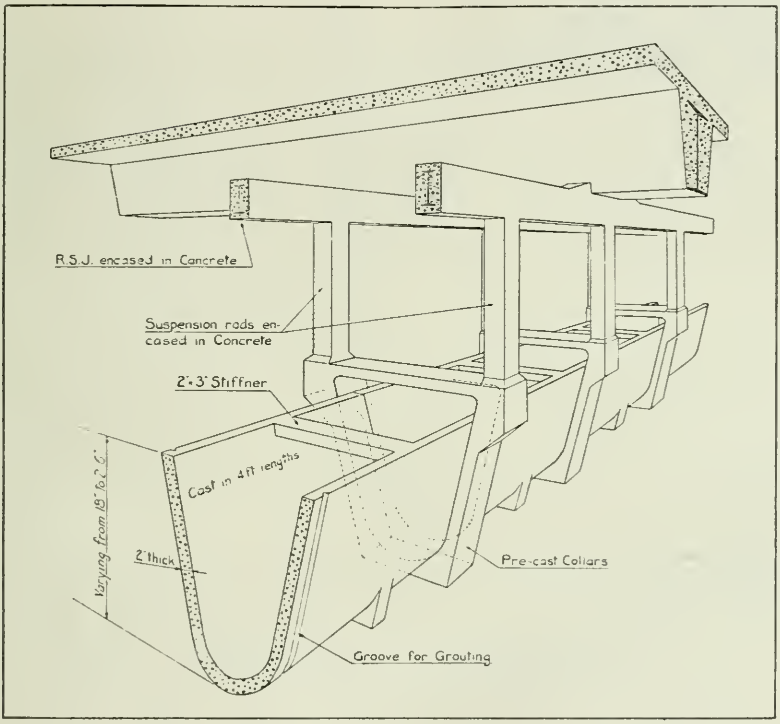

R.S.J. encased in Concrete
Suspension rods encased in Concrete
2"×3" Stiffner
Cast in 4 ft lengths
Varying from 18" to 2' 6"
2" thick
Pre-cast Collars
Groove for Grouting

FIG. 3. SKETCH SHOWING GENERAL ARRANGEMENT OF DRAIN UNDER FLOOR.

The construction of this drain under the floor, together with the various catch pits and the external work composing the egg-shaped drain, sumps, beams, piling, etc., was carried out by Messrs. Edwards Construction Company, Ltd., of Blackheath, and the excellent quality of the finished work and the highly satisfactory results of the tests are greatly to their credit, having regard to the difficulties previously mentioned, and the fact that most of the external work was carried out below the high-water level of the river. This latter condition necessitated the construction being done within sheet-piling, and even when this was done, continuous pumping was found to be essential during the whole time of construction of the work below water-level.

LOWESTOFT HOUSING SCHEME.

LOWESTOFT affords yet another example of the successful introduction of a concrete form of construction as a means of overcoming the brick shortage and the labour difficulty, by substituting the concrete block for brickwork and unskilled for skilled labour. The full scheme of the Lowestoft Borough represents some 290 houses, planned at ten to the acre and built in blocks of two and four. The first houses to be built were of brick, and twenty-two were put out to contract in November, 1919, and obtained by Mr. Hipperson, of Norwich, at an average cost of £850. These were parlour-type houses planned with the bathroom on the ground floor. During the early part of 1920, however, owing to the shortage of bricks and the proposals of the Standardisation and Construction Committee of the Ministry of Health to consider new methods of construction, a scheme was devised

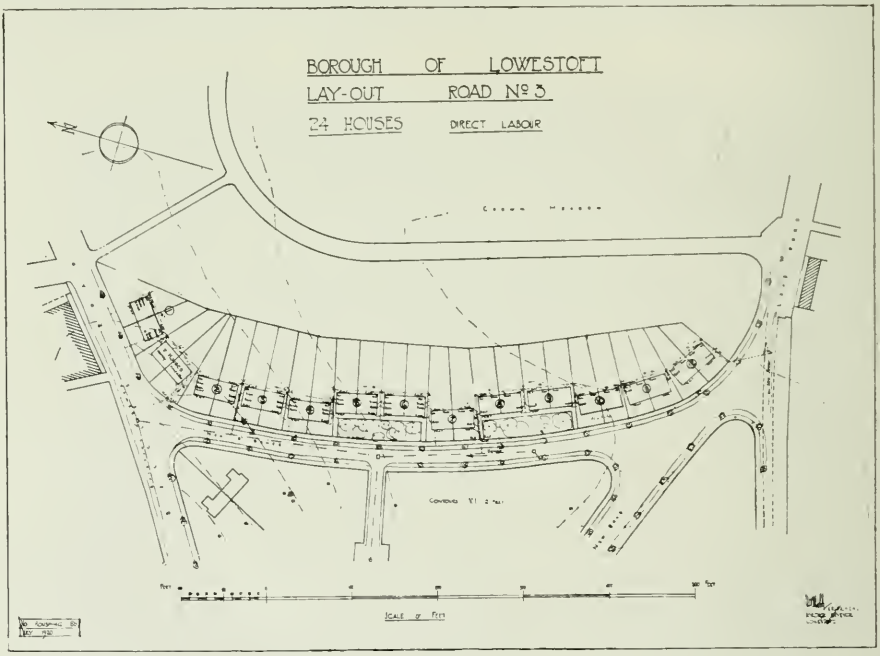


FIG. 1. LAYOUT.

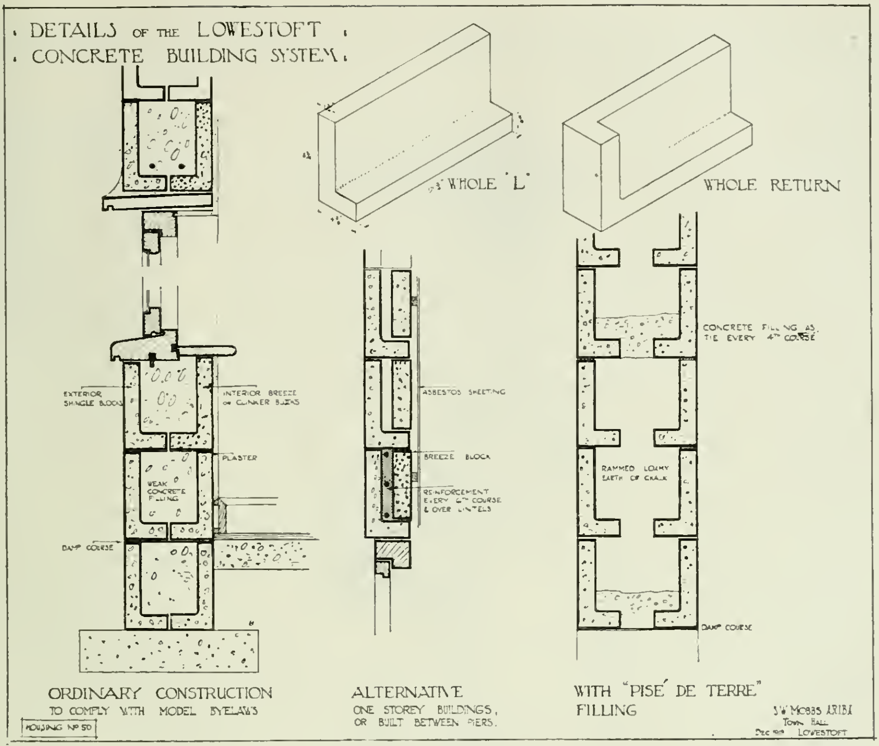


FIG. 2. SHOWING METHOD OF CONSTRUCTION.

by Mr. Mobbs, A.R.I.B.A., the Borough Surveyor, which was subsequently known as the " Lowestoft " Concrete Building system and received the approval of the

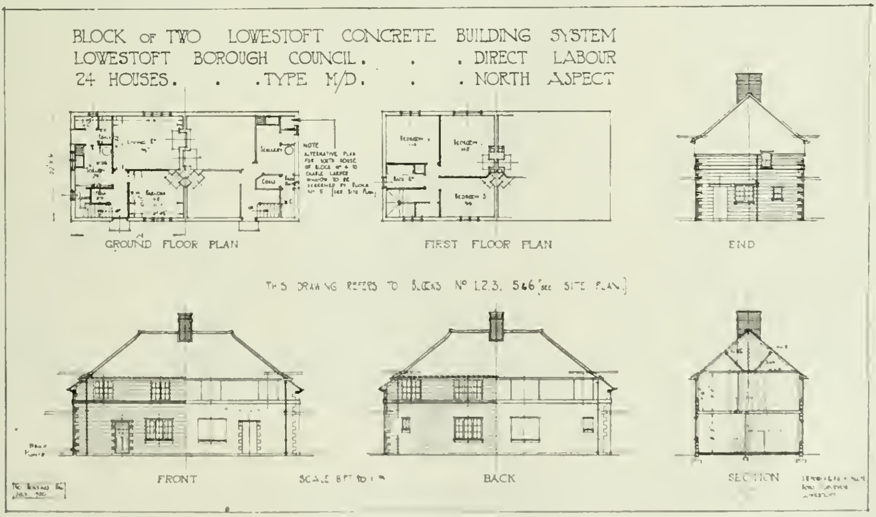
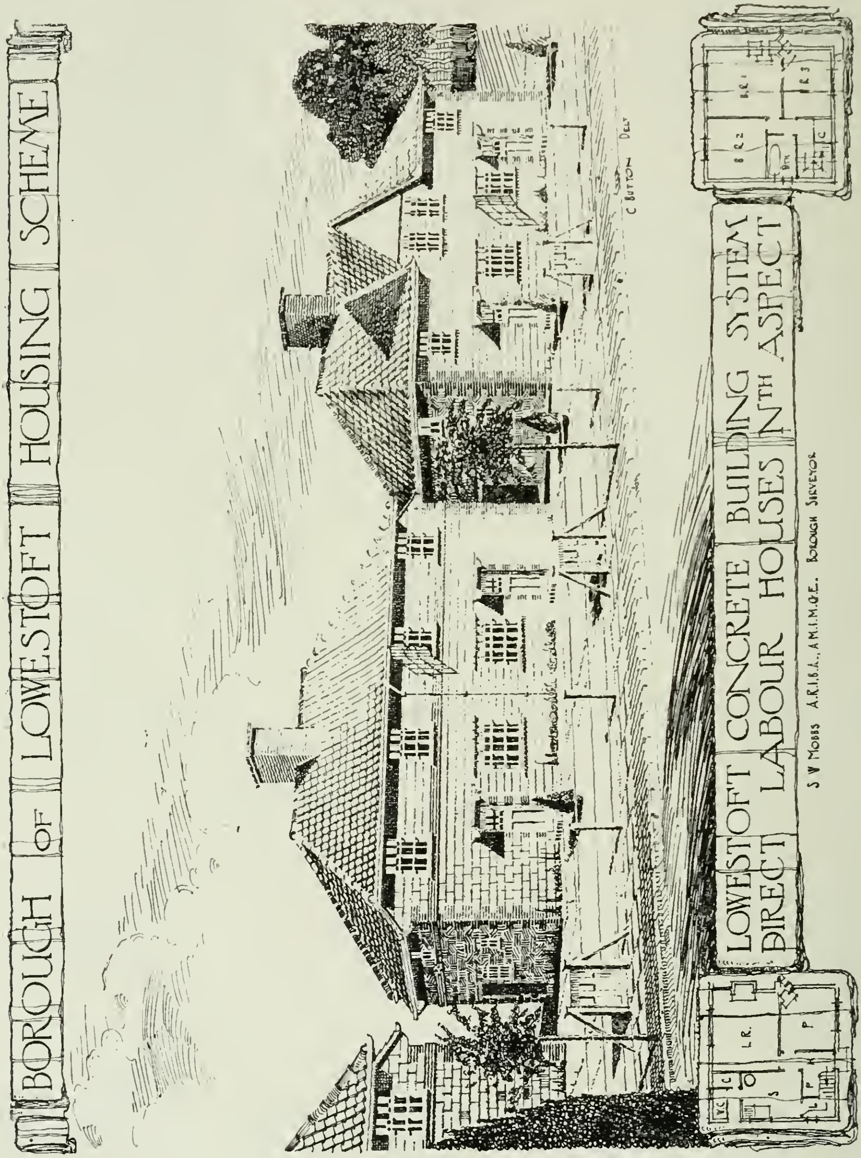

BLOCK OF TWO LOWESTOFT CONCRETE BUILDING SYSTEM
LOWESTOFT BOROUGH COUNCIL. . . DIRECT LABOUR
24 HOUSES. . . TYPE M/D. . . NORTH ASPECT
GROUND FLOOR PLAN
FIRST FLOOR PLAN
END
THIS DRAWING REFERS TO BLOCKS No 1.2.3. 5&6 (SEE SITE PLAN)
FRONT
SCALE 8 FT TO 1 IN
BACK
SECTION

FIG. 3. PLANS AND ELEVATIONS.

Ministry of Health. The system, which will be described in detail later, was then employed on a further twenty-four houses which are being built by direct labour. The grouping of these houses is shown on the lay-out plan, *Fig.* 1.


BOROUGH OF LOWESTOFT HOUSING SCHEME
LOWESTOFT CONCRETE BUILDING SYSTEM
DIRECT LABOUR HOUSES NTH ASPECT
S W Mobbs A.R.I.B.A., A.M.I.M.C.E. Borough Surveyor
C Button Delt
B.R.1
B.R.2
B.R.3
L.R.
S
P
W.C

The plans that are reproduced for a south and north aspect house are compact and free from irregularities in outline, nevertheless the elevations are entirely satisfactory. The brick quoins are in keeping with the east county traditions, and the brick string course is a pleasing feature, likewise the simple treatment of the front door. The roofs are covered with Norfolk pantiles. A most picturesque and successful covering for a roof free from many hips and valleys.

The key to the method of construction consists in the use of an L-shaped block, but unlike other systems which have used a similar unit, the L applies to the section and not the plan. Thus the ordinary wall is built up of two blocks with a small clearance between their feet and the space filled in with a weak 16 to 1 mixture. This interior filling is added to each course of blocks as it is laid and the aggregate used is clinker, coke-breeze or shingle, and the mixture is well rammed and screened off. The blocks have also been used with a filling of *pisé-de-terre*; in such cases they are spaced further apart and every fourth course is partly filled with concrete, acting as a homogeneous tie. A third method is shown by which an ordinary rectangular block is placed between the feet, and a filling of concrete, reinforced for every sixth course, and over openings, employed as before. This method of walling is considered suitable between piers or for one-storey buildings.

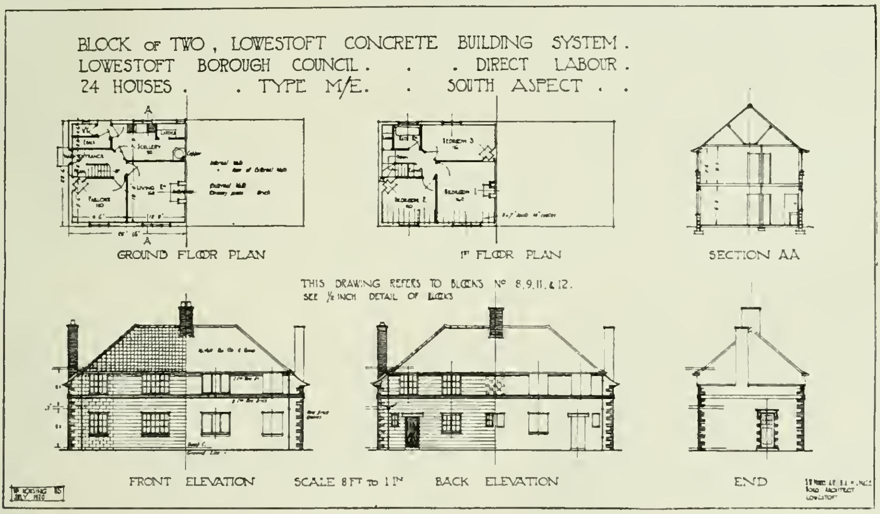

BLOCK OF TWO, LOWESTOFT CONCRETE BUILDING SYSTEM.
LOWESTOFT BOROUGH COUNCIL. . . DIRECT LABOUR.
24 HOUSES. . TYPE M/E. . SOUTH ASPECT. .
A
A
GROUND FLOOR PLAN
1ST FLOOR PLAN
SECTION AA
THIS DRAWING REFERS TO BLOCKS Nº 8, 9, 11, & 12.
SEE ½ INCH DETAIL OF BLOCKS
FRONT ELEVATION
SCALE 8 FT TO 1 IN
BACK ELEVATION
END
JULY 1920
BOROUGH ARCHITECT
LOWESTOFT

Fig. 4. Plans and Elevations.

The blocks are made by unskilled labour in simple steel moulds which were designed by Mr. Mobbs and made at the Corporation yard. The body of the facing block is composed of 4 parts aggregate to 1 part cement, with a sufficiency of water added to mix to a plastic consistency, and faced with cement and sand mixed 1 : 2, the concrete being well tamped in the mould. Various patterns of blocks are made to ensure perfect bonding, consistency of whole Ls 18 in. by 9 in., ¾ Ls 13½ in. by 9 in., and ½ Ls 9 in. by 9 in., together with whole and half returns. The interior Ls are composed of 4 parts clean clinker or breeze, 1 part sand and 1 part cement and finished with a rough face to afford a key for plastering. The internal walls are built up of 3 in. solid breeze block, 18 in. by 9 in., and bedded in lime mortar gauged up with cement, the fireplaces and chimneys being of brick.

The cost of these houses is about £850; this price is of course based on the labour rates in use prior to the recent drop, and is a favourable one for parlour-type houses.

CONCRETE CONSTRUCTION AT WORCESTER.

By WILLIAM RANSOM, A.M.I.C.E., City Surveyor.

The Worcester Housing Committee in one of their Housing Schemes, situated at Northwick, about one and a half miles from the centre of the town, have embarked upon an experimental form of concrete construction.

It was felt that an effort should be made to build with materials other than brick, and various methods were inspected at Bournville, Leeds, Birmingham, etc. The special system of concrete construction which appealed most to the Committee was the Re-Con-Block system, which has been developed by Mr. J. Mitchell, a New Zealand architect of repute, and a former Government official. The war had prevented his return to New Zealand, and he has been utilising the time in developing his system.

It was decided to erect a pair of bungalows, and designs were prepared by Messrs. J. H. Williams and P. H. Smith, architects, of Worcester. The bungalows have been erected by direct labour, but owing to a trade dispute the actual work of completion has been entrusted to a contractor, so that at present the cost cannot be ascertained.

The Committee have been advised not to expect any saving in the cost of concrete construction over that of brick construction. It is quite possible that where organisation is provided for an extended scheme that it would be possible to build a little cheaper.

The plan and elevation of the bungalows are shown in *Fig.* 2.

The walls are 4 in. thick and were made waterproof by an external coat of stucco. It is proposed to build some houses upon the same system of construction, but with cavity walls.

The concrete blocks are made of six parts clinker and sand and one part of Portland cement. The blocks are made in a special hand machine which moulds and rams the material. They are made with a groove at the top and a vertical hole 1 in. diameter through the centre. The blocks are 16 in. wide on one face and 13 in. on the other face as shown on the diagram (see *Fig.* 1). The blocks are reinforced with mild steel bars. Vertical bars 16 in. long, $\frac{1}{2}$ in. by $\frac{1}{8}$ in., are placed in the 1 in. diameter centre holes of the block, and $\frac{1}{4}$ in. round horizontal pieces, 8 in. long, are attached to the vertical bars, and are laid in the groove on the top of the block. The vertical bars pass through one course of blocks into the cavity at the junction between two blocks in the lower course. The vertical holes, junction cavity and horizontal grooves are all filled in with liquid cement, and when set the work forms a compact mass of surprising strength.

Where cavity walls are to be erected upon the Re-Con-Block system special distance pieces are made of a non-absorbent concrete. These distance pieces enable the craftsman to automatically regulate the line of the wall he is building. Joinery can be fixed direct to the blocks, but it is preferable to insert special dovetailed grounds in the blocks when made, and which can be placed in position in the wall to secure the joinery.

These dovetailed grounds will not work loose, and avoid the necessity of plugging the wall.

The term *Re-Con-Block* is an abbreviation for reinforced concrete blocks. The system of construction is an attempt to place concrete construction for houses

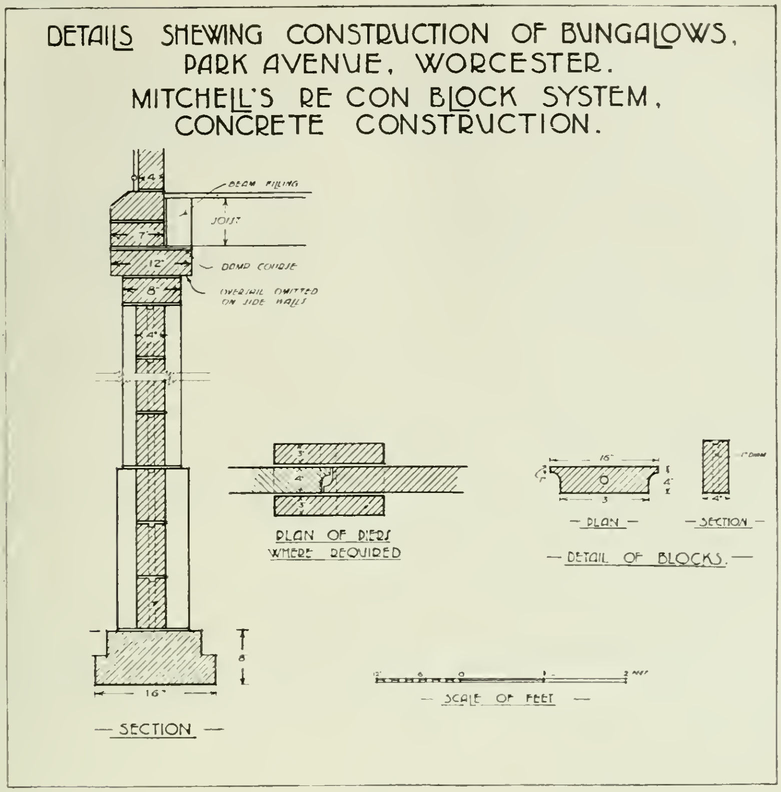

DETAILS SHEWING CONSTRUCTION OF BUNGALOWS, PARK AVENUE, WORCESTER.
MITCHELL'S RE CON BLOCK SYSTEM, CONCRETE CONSTRUCTION.
BEAM FILLING
JOIST
DAMP COURSE
OVERSAIL OMITTED ON SIDE WALLS
4"
7"
12"
8"
4"
16"
SECTION
3"
4"
3"
PLAN OF PIERS WHERE REQUIRED
16"
3
4"
1" Diam
4"
PLAN
SECTION
DETAIL OF BLOCKS.
SCALE OF FEET

Fig. 1.

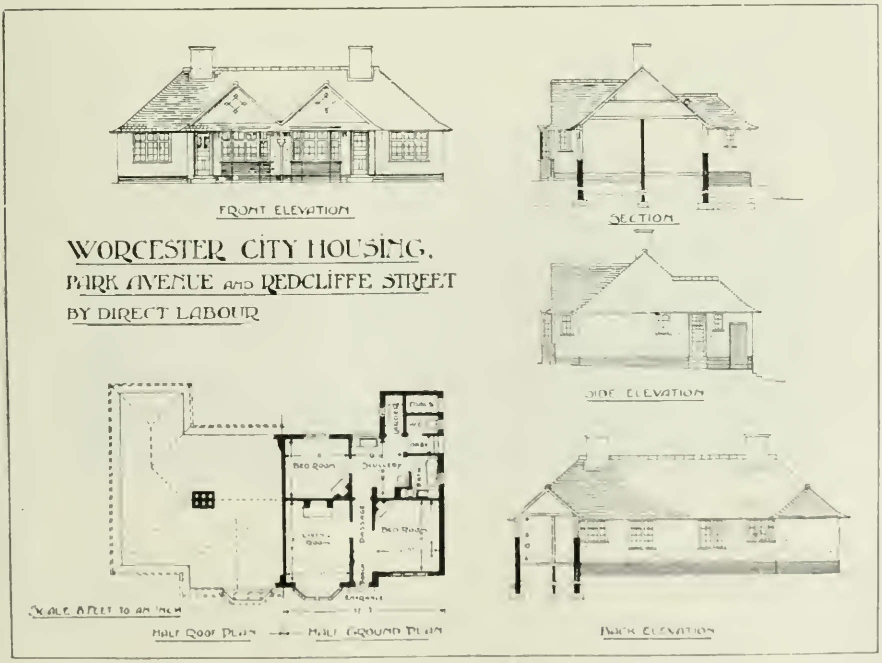


Fig. 2. Plan and Elevations.

upon an economical basis and to provide an outlet for as large a proportion as possible of unskilled labour. The blocks form a standard concrete unit which can be easily handled, erected, and reinforced to form the outer skin of walls of any thickness, piers, etc., and provide walling of any thickness either single, or used in connection with a cavity.

The machine which is used for the manufacture of the blocks is simple in construction and can be handled by unskilled labour under technical supervision. Crushed clinker has been utilised in the manufacture of the blocks, but almost any local material could be utilized if proper attention be given to proportioning and maturing the blocks.

The unit adopted for the block has been determined by considerations of weight. It is found by experience that the craftsman cannot handle with ease blocks of a greater weight than 28 lb. if his trowel hand is to be left free and ready for use.

The reinforcements which are used are quite small and placed in position as the work proceeds. It is recommended that the reinforcements should also be used in the interior walls as a safeguard against cracks, etc., which are always likely to develop from the slamming of doors.

The joists in the houses are fixed upon an oversailing course and not built direct into the wall.

The bungalows have an artistic appearance, and have quite overcome local prejudice against concrete construction. There have been many applications to rent them, and the Housing Committee will have no difficulty in securing the best of tenants.

THE FINISHED BUNGALOW.

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

It seems a very great pity that English architects are so backward in development as regards the æsthetic treatment of Reinforced Concrete buildings. Why should it be left to other countries to show evidence of that *simpatia*, that relation between material and design (using this word in its limited signification), when by all precedent we should be in the forefront in such matters ?

It is no use at all for architects to consider that design consists in mere copyism, in " decorating " a surface with pilasters or columns, architraves or pediments. Such treatment answers most suitably for a material such as stone, where the relation between the body and the soul is obviously intimate.

Though some superficial delightful effects may be obtained by using columns and similar features in brickwork, yet the inherent æsthetic suitability is entirely non-existent. Columns and pilasters are essentially in their origin destined to carry heavy loads, and should therefore be built up of large drums or blocks, and not be frittered away in 2 in. or 3 in. layers, where they rightly demand 2 ft. 6 in. or 3 ft.

And again the nature of certain stones lends itself to ornamental carving, both fine and bold, whereas other stones, such as granite, admit of broad treatment only. Bricks, too, have their own suitable treatment ; and to introduce shallow pilasters and arches, where it is apparent that nothing constructional is involved, is quite *en règle.*

In any case, however, arches are perfectly suitable treatment for brickwork, for it involves the gradual spreading of a load, or rather, the dispersion of the load, so as to be carried to abutments, in place of its forming a direct load for immediate vertical resistance.

And it would be similarly possible to discuss the *raison d'être* of various other features, which are, however, too often regarded merely as an end in themselves, instead of being by rights a mere means to an end.

It has been allowed above, that it may be justifiable to use some feature in decoration, which should be strictly regarded as constructional (using this word in its engineering sense). But the exercise of such an æsthetic privilege should be a matter of cautious consideration.

Of course one of the great evils of so-called design is when " shams," obvious or otherwise, are introduced ; such as, for instance, the lining-up of stucco in imitation of stone courses, the marbling of stucco in the vain hope that it may be mistaken for Brescia or Sienna or Rouge Royal, the graining of deal to represent oak and other hard woods. I read recently that Scagliola should not be regarded as a sham, but I confess that I can see no reason for such a concession.

Ethically the more successful the sham the worse it is ; practically, of course, the opposite is true. But it all comes back to this, namely, that architects may well be satisfied to treat each material with its own suitable decoration.

We hear people say, and say rightly, that the secret of good ornament is, that decoration should be constructive, not constructed. In other words, it should follow the nature of the material and of the building.

In this way we find a suitable treatment for stucco to consist in Sgraffito, in shallow stencilling or similar design, in panelling, and even in vermiculation, which treatment possesses certain limited advantages.

I am prepared to be original, if necessary, in the expression of views as to the suitable decorative treatment for Reinforced Concrete façades. Why should not the effect be tried of expressing on the surface the internal construction of the system, modified as far as may be desirable, to obviate crudity ?

Just as the human anatomy is expressed on the surface, with the many and necessary modifications, so with Reinforced Concrete the anatomical *emphasia* might form the basis of true æsthetic design.

The muscles, the ribs, the veins—all help in the expression of the human design externally ; similarly the bars in their varying dispositions, the wiring and other features of Reinforced Concrete construction might be properly emphasised exteriorly—at any rate, it is worth while for architects to try this method of design.

I know that some hold the view, that obvious shams are not shams at all, and are therefore unobjectionable, but I cannot agree with this heresy.

CONCRETE AGGREGATES—*(continued).*

The Concrete Institute takes no responsibility for the accuracy of the information supplied.

(47) **Ilkeston (Derbyshire)** :—Bermerley slag, with high sulphur contents (R.C.B.).

(48) **Irlam-o'-th'-Height (Lancashire)** :—Gravel ; this is dirty and needs washing (R.C.B.).

(49) **Islip (Oxfordshire)** :—Furnace slag, containing a large amount of sulphur (R.C.B.).

(50) **Kidderminster (Worcestershire)** :—Sand, containing 16 per cent. loam (R.C.B.).

(51) **Kingswinford (Worcestershire)** :—Mr. W. Meredith, Surveyor to the Rural District Council, writes that he is " not aware of any natural source of supply in the district ; there are some slag mounds, from which aggregate could be obtained, were crushing plant installed."

(52) **Kinross-shire** :—

General description : Whinstone.
Source and locality of same : Quarry (Glenfarg).
How obtained : Quarrying.
From whom obtained : J. Deas, Glenfarg (owner).
Is available quantity limited ? No.
Present maximum output per day : (1919) 100 tons.
Transport facilities : North British Railway.
Is there any provision at or near source for washing or crushing ? Yes.
Kind of stone or coarse material : Whinstone.
Kind of sand or fine material : Whinstone.
Relative proportions of coarse and fine material : Vary.
Shape of particles : Angular.
Size of particles ; approximate percentage that needs crushing to pass $\frac{3}{4}$ in. Screen : $2\frac{1}{2}$ in. angular, $1\frac{1}{2}$ in. to $\frac{1}{4}$ in. angular small. All needs crushing for $\frac{3}{4}$ in. screen.
Impurities present : None.
Source of information : T. G. Welburn, Architect, Milnathort.
General remarks : Used at Naval Base and various other works in the Counties of Fife, Kinross, Clackmannan, and Stirling.

LAND SUBSIDENCE AND ITS EFFECT ON CONCRETE AND OTHER STRUCTURES.

By LAWSON S. WHITE, A.M.C.I., A.M.Inst.C.E.

Abstract from a Paper read at the One Hundred and Fifth Ordinary General Meeting of the Concrete Institute on Thursday, May 26th, 1921.

THE author was engaged in construction work in Canada for several years before the war and during that period was fortunate enough to witness some very interesting cases of foundation failures, which prompted him to study this subject and to prepare these notes.

Need for Investigation.—Pointing to the need of research, the author said that since concrete, both plain and reinforced, is extensively used in foundations, their failure is of particular interest to the concrete engineer, who may also be called upon to construct retaining walls and buttresses to counteract the effects of the subsidence of large tracts of ground. Again, the sliding of earth behind a retaining wall on an unexpected plane may easily upset all the provisions the engineer has made for the stability of the wall. The structural engineer, too, should be well acquainted with the behaviour of the soil, and make the necessary allowance for cases in which subsidence is to be expected, for a weak point in design often falls victim to a settlement.

Bearing Capacity of Soils.—The first consideration in designing the foundations of a structure is the bearing capacity of the ground.

For small work the rule of thumb calculation for bearing values is usually all that is required, provided that local conditions are respected ; but for heavier work, where large areas are covered and big sums of money expended, more accurate methods, following a thorough investigation, are essential.

Early Theory and Practice.—One of the earliest theorists to submit a mathematical treatment of earth pressures was Rankine.

Many engineers have since realised the unsatisfactory results which come from applying Rankine's formula to soils of a different character to that of sand, such as clay, etc., and valuable experimental research by Darwin, Wilson, Bell, Crosthwaite and others has shown that cohesion plays an important part in each pressure.

The uncertain and unstable nature of cohesion in soils forbids a definite classification of cohesive values. In many cases cohesion is largely attributable to water content, a certain percentage of which gives a maximum cohesive value. Should the water either dry out or increase in quantity—contingencies most certainly to be expected—the cohesive value is quickly changed. If, therefore, a value for cohesion is assigned to a certain soil, due care should be taken that the character of that soil is not influenced by external agencies.

More recent investigations have tended to show that earth in foundations behaves somewhat as an elastic solid of low strength and low shearing value. It might therefore be treated as any other structural material when its relation of stress to strain, or load to settlement, has been ascertained. The elasticity of earth is commonly observed by a slight swelling or rising of ground after a load is released. Mr. J. F. Greathead for the Public Service Commission of America conducted many experiments, the principal results of which seem to indicate that the elastic rebound is quite appreciable, but that the settlement on reapplication of the load is considerably greater than the recovery.

Earthquakes.—The subsidence due to earthquakes is beyond the scope of this paper, but it is worthy of note that in countries (such as Italy) which are subject to volcanic action, an increasing effort is being made to construct anti-seismic buildings, for which, for obvious reasons, reinforced concrete is an ideal material. In one instance, after an earthquake in an Italian village, a reinforced concrete structure was the only building left standing there.

Causes of Soil Failures.—Let us now consider under what conditions the state of the soil contributes to the failure of foundations. The committee appointed by the American Society of Civil Engineers has drawn up the following comprehensive and suggestive table which is reproduced in full.

Foundations fail and bearing capacity of soils becomes deficient by reason of:

- (1) Compression
  - (*a*) From unequal loading within the elastic limit of the soil.
  - (*b*) From loss of cohesion.
  - (*c*) From crushing edges of the grains.
  - (*d*) From shrinkage of organic matter.
  - (*e*) From loss of water content.
- (2) Flowing
  - (*f*) From saturation.
  - (*g*) From lack of cohesion under the influence of weight and pressure.
  - (*h*) From exceeding cohesive strength.
- (3) Sliding
  - (*j*) From sliding of bodies of material on an underlying and usually inclined layer of lubricating material frequently aided by water.
  - (*k*) From sliding of material previously immersed when water level is quickly lowered.
  - (*l*) From sliding of a structure on the soil.
  - (*m*) From sliding of a structure together with the soil.
- (4) Erosion
  - (*n*) From flowing water and the fluctuation of the water-table.
  - (*o*) From the wind.
- (5) Chemical changes
  - (*p*) From weathering and frost.
  - (*q*) From possible chemical influences.

It would appear very advisable that a careful investigation of soil conditions should be made before the foundations of any large work are planned.

Coast Erosion.—The sea is one of the most troublesome and relentless of destructive agents, and examples of its effects are only too frequent.

Local Erosion.—River erosion, either by an alteration in the direction of flow or by a scouring of the channel, is chiefly to be expected in countries subject to torrential downpours. Exceptional floods may open up a new course or undermine and destroy existing structures.

It often happens in gravel soils that a stream flows beneath the surface. Near a river, where a heavy building is founded on an alluvial deposit which covers the ballast bed, the soil may be forced down to a level at which it becomes affected by the erosive action of the flowing water. In such cases it is advisable to take the foundation down to ballast.

Careless construction of drains and water mains is a frequent cause of destruction of property in towns. A leakage generally grows, and may ultimately wash away the earth in its passage, and thus often causes an ugly settlement where it has access to the foundation bed of a building.

Subterranean Workings.—In mining districts where careless methods have been employed, subsidence of large areas of land with consequent destruction of property is only to be expected. Instances are quite common in the coalfields where the seam is near the surface, and they are also very frequent in salt-mining districts. The remedy lies in careful backfilling after mining, or in the provision of adequate permanent supports. An irrecoverable waste of valuable fuel is caused by leaving 30 per cent. of the coal seams in pillars to support the roof.

Organic Interruption.—Buildings founded on timber grillages often subside because of the decay of the timber. If the water level changes constantly, and the foundation is subject to alternate wet and dry periods, this decay is rapid ; but timber may last well in earth always saturated with water. Top soil must be avoided as a foundation for buildings and, if feasible, for embankments, since it is honeycombed with worm holes and root channels, and it should always be stripped to a sound depth.

An unusual instance of failure, due to the crushing of top soil, was that of a reinforced concrete aqueduct at Winnipeg, which, for gradient purposes, had to be placed at ground level. The settlement caused large cracks in the invert. These were remedied by a wedge-shaped cement filling.

Chemical Action.—Vegetable soils, such as peat, gradually decompose and lose volume. Allowance should be made for this shrinkage. Water in alkaline soils attacks and rots concrete. One of many typical instances is that of the Winnipeg drainage system, where about forty miles of concrete sewers were said to be in a state of collapse, the concrete having rotted away to such an extent that it could be picked away by hand. Knowledge of this chemical action is too recent to have suggested a suitable remedy—apart from waterproofing.

Natural Shrinkage of Ground.—Where large tracts of marshy ground, with thick peaty top soil, are drained, a considerable subsidence takes place. This is due to three main causes—drying, decay and cultivation. Parts of the Fenland sank through 10 ft. between 1848–1913, and similar conditions have been observed by C. W. Okey during the reclamation of muck and peatlands in Southern Louisiana and Florida.*

Shrinkage of Earthworks.—It is a moot point with engineers whether or not earth taken from a cutting shrinks when made into an embankment. From exhaustive investigation of actual works it would appear that in calculating excavation quantities an allowance should be made. It would be difficult to compact earth more closely than nature does, and the density of the soil increases with its depth. Top soils, however, contain a considerable percentage of voids caused by frost or organic action ; and since most embankments are built of soil of this nature, taken from shallow excavations, it is only to be expected that, quite apart from apparent shrinkage of volume due to subsidence of foundation beds and loss of volume due to transportation from cut to fill, or else due to rain erosion, a decrease in volume will result from handling the deposition ,and subsequent pressure in the fill.

Made-up ground takes time to settle finally, in spite of most careful watering and rolling in deposition. " Hydraulicking," a modern method of building large fills by pumping the material into place with water, resembles more closely the natural method of formation and produces best results.

Unless it is thoroughly investigated and tested, " made-up " ground should be avoided as a foundation bed for heavy buildings.

Weather Effects.—Reference has already been made to frost action. In countries which experience severe cold the soil is sometimes frozen to a depth of from 4 ft. to 6 ft. and consequently its cohesion is impaired and its bearing power becomes uncertain. Every building foundation should be placed below the frost line, to avoid failure either by upheaval through expansion by frost or by subsidence on account of the weakness of frost-loosened soil.

On works, such as new roads, where very shallow foundations only are practicable, great care must be taken over the drainage of the subgrade. There are instances without number in which a waterlogged subsoil has frozen and caused wholesale bursting up of miles of new roadways.

Clay soils are very sensitive to weather changes, since they swell considerably when wet and contract when dry. This generally accounts for the all too frequent sight of cracked or leaning garden walls and gate piers. To avoid frost and weather action it is advisable to lay foundations, according to local conditions, at from 5 ft. to 8 ft. below the surface.

(To be concluded in the next issue).

SECRETARY'S NOTES *(continued from p. 510).*

ERRATUM.

Regarding the notes published in July (page 433) we are requested to state that the crushing strength of the sandstone quarried by Messrs. B. Whitaker & Sons, Leeds, should have been given as 552·2 *tons per square foot, not lbs.*

The next Examination for Graduateship and Associate-Membership of the Concrete Institute will be held on Thursday, October 20th, and Friday, October 21st, 1921, in London, and at Salford, Edinburgh and Cork. Applications for all particulars should be addressed to the Secretary, Concrete Institute, Denison House, 296, Vauxhall Bridge Road, Westminster, S.W.1.

All applications for sitting for these Examinations must be received not later than September 22nd next.

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* *The Subsidence of Muck and Peat Soils in Southern Louisiana and Florida.*

CONCRETE IN AGRICULTURE.

CONVINCING DISPLAY AT THE ROYAL AGRICULTURAL SHOW.

THE value of concrete to the estate owner and the agriculturist is no new topic in the pages of this journal. Year by year new uses are found for this material, and year by year new channels are opened up for the exploration of its possibilities, and each exploration leads to some new discovery.

The practical utility of concrete for use on the land was illustrated in a very convincing manner by the exhibits on the stand of the Concrete Utilities Bureau at the Royal Agricultural Show at Derby. This exhibit has now come to be regarded as one of the outstanding features of the Show, and one of the first questions in the minds of those who visit the stand year after year is "Is there anything new?" So far, the answer has never taken the form of a negative. That this year's display is no exception will be seen from the description with which our representative, after a personal inspection, has furnished us.

In the first place, the stand itself is of no mean proportions, being 125 ft. long by 65 ft. wide. Its general appearance will be seen in *Fig.* 1. It was constructed of concrete block columns, on which steel trusses supported a roof of corrugated cement-asbestos sheets, the product of the British Fibro-cement Works, Ltd., of Erith, Kent, the gables being filled in with plain sheets of the same material. The fact that this form of roofing renders a building cool in summer was illustrated in a remarkable manner, for, in spite of the great heat which prevailed during the Show week, the temperature in this stand was at no time excessive; and, as a matter of fact, the non-conducting property of this material is such that it renders a building not only cooler in summer but warmer in winter. Two of the corners of the stand were enclosed with solid concrete walls, and, in order to provide examples of different forms of surface treatment, the outer surfaces of these walls had been rough-cast or pebble-dashed.

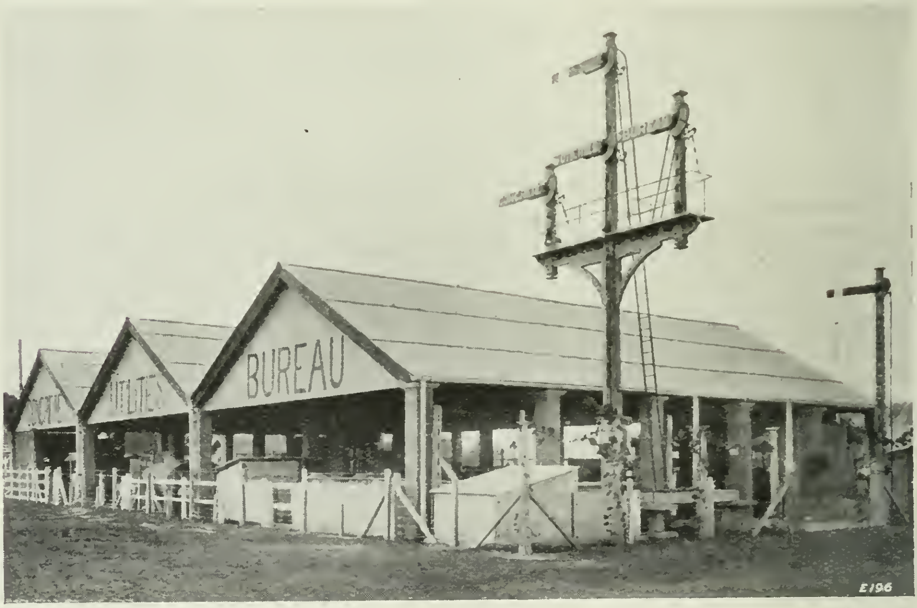


FIG. 1. GENERAL VIEW OF THE CONCRETE UTILITIES BUREAU STAND.

Unfortunately, the artistic side of concrete, as far as surface effects are concerned, has received but little attention in this country, and a number of panels illustrating the possibilities of the material in this direction, produced by a simple but little-known method, were very illuminating. This method is fully described in the Bureau pamphlet, No. 14, recently issued.

A feature of the stand which caused considerable comment was the guttering and down-pipes with which the structure was equipped. This was entirely of cement-asbestos, provided by the British Everite and Asbestilite Works, Ltd., of 29, Peter Street, Manchester, and was illustrative of the remarkable advance made in this form of concrete, which is neat in appearance and exceedingly strong. This may be seen in *Fig.* 1.

Messrs. Centrifugal Concrete Blocks and Poles, Ltd., who have recently taken over the concrete work of the Lilleshall Company, exhibited a fine example of a standing for two cows, the stall divisions, manger and floors being all of concrete. In addition, they showed a concrete window frame set in a wall of hollow building blocks which, in section, are square on the outside, with a circular aperture within. It was rather a surprise to learn that these blocks, as well as the window sill and head ledge, were made by the centrifugal process. The window and the wall are seen in *Fig.* 2.

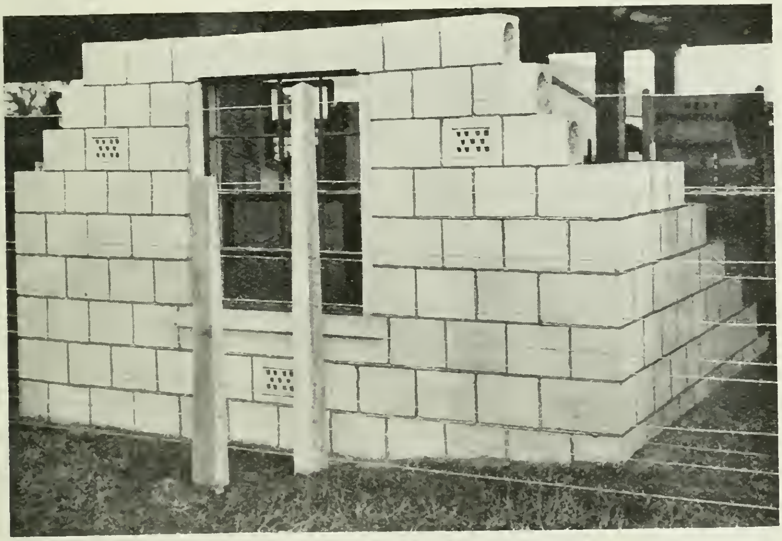


Fig. 2. Concrete Wall, Window Frame and Fence Posts.

Since the erection of buildings of various kinds, whether cottages, farm buildings or garages, is a matter of import to the estate owner, it is not surprising that the exhibit of Messrs. Concrete Dwellings, Ltd., 1, Carteret Street, Westminster, attracted a good deal of attention. This firm has patented a travelling mould, previously described in this journal, for building, *in situ*, concrete walls, either cavity or monolithic, and demonstrations of its operation were given at frequent intervals daily.

Another firm which, as far as we know, made its first public appearance in this country at the Building Trades Exhibition at Olympia in April last, is " C. R. Building Constructions, Ltd.," 19, Castle Street, Falcon Square, E.C.1. Judging from the present exhibit the speciality of this firm appears to be fencing, and the examples shown included a cattle pen, seen in *Fig.* 3, and also what they describe as a " Cattle proof fence," which is made up of concrete posts with a twisted ribbon as the top strand and barbed wire for each of the others.

The corner occupied by the Croft Granite Company, of Croft, near Leicester, contained exhibits of a useful and interesting nature. One was an example of their patent concrete floor and roof, which seems to us not only ingenious but effective. A description of this, however, must be deferred to a later issue. This floor and roof form portion of a partly-built room containing 4-light and 2-light windows, the frames of which are of concrete.

If any evidence were wanting as to the durability of concrete it would be found in another exhibit of the Croft Company consisting of a couple of moulded medallions, one twenty-five years old, and the other thirty-five, together with a concrete grid of about the same age. This firm also showed sewer pipes, wire and rail fencing, gate posts, troughs, ornamental vases and pedestals and clothes line posts. Many of these articles can be seen in *Fig.* 4, which is a view of the " Croft " corner.

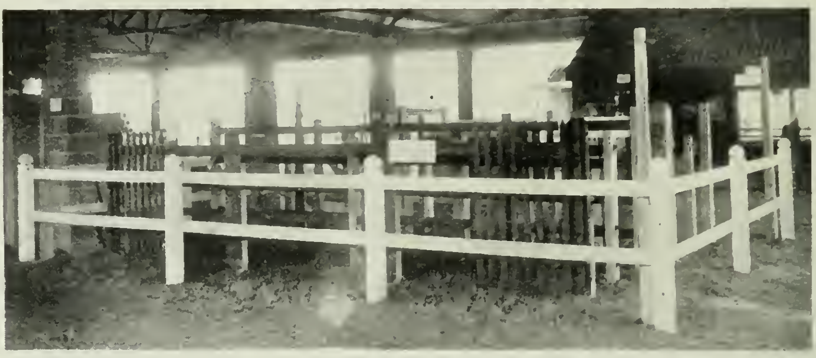


Fig. 3. An All-Concrete Cattle Pen.

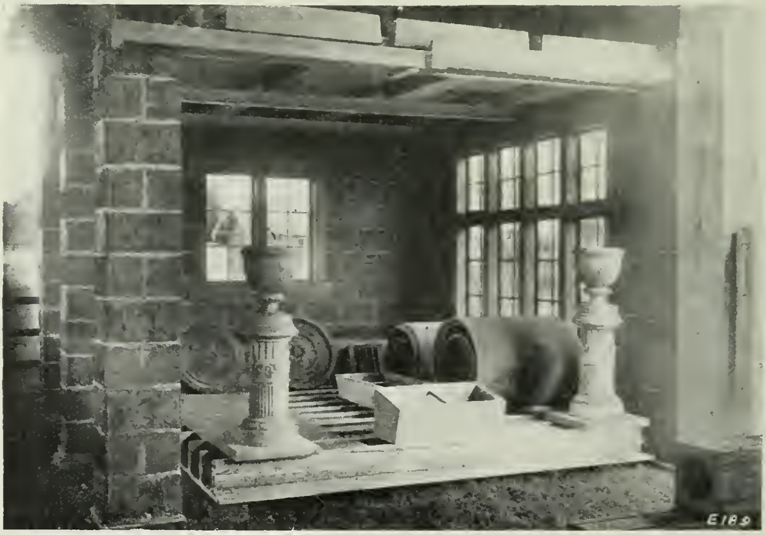


Fig. 4. An Interesting Corner showing Concrete Flooring and Roofing, Building Blocks, Pipes, Troughs, and Ornamental Products. The Medallions and Grid, from 25 to 35 years old, are seen at the back.

At one side of the stand a full-width section of reinforced concrete roadway had been laid, showing the method of construction, and for the sides of this the Croft Granite Company had supplied a combined kerb and channel and concrete footpath. This exhibit, a portion of which may be seen in *Fig.* 6, was of especial interest to representatives of Municipal Authorities.

Messrs. Evans Bros., of Riddings, Alfreton, showed some concrete products which are out of the common. For example, a concrete rick-stand on concrete supports, which is rat-proof—and what an important consideration this is farmers best know ; wire netting tennis surrounds supported by concrete posts (seen in *Fig.* 1), tubs for shrubs or small trees, a garden frame (*Fig.* 5) and four clothes line posts, two of which may be seen in *Fig.* 3. In addition to the above this firm showed drinking troughs, paving slabs and various forms of fencing and gate posts.

Messrs. Girlings' Ferro-Concrete Fencing Co. have, as their name suggests, made a speciality of fencing, and their exhibits included concrete posts and ordinary wire fencing, substantial gateposts carrying a 9-ft. gate and a length of wire fencing especially adapted to housing schemes.

One set of exhibits seen in *Fig.* 6 caught the eye at once. This set, consisting of troughs of various kinds, a cow manger and a kitchen sink, were the work of Mr. R. Mosley, of Chelmorton, Buxton, and were not only useful, but neat and well-finished.

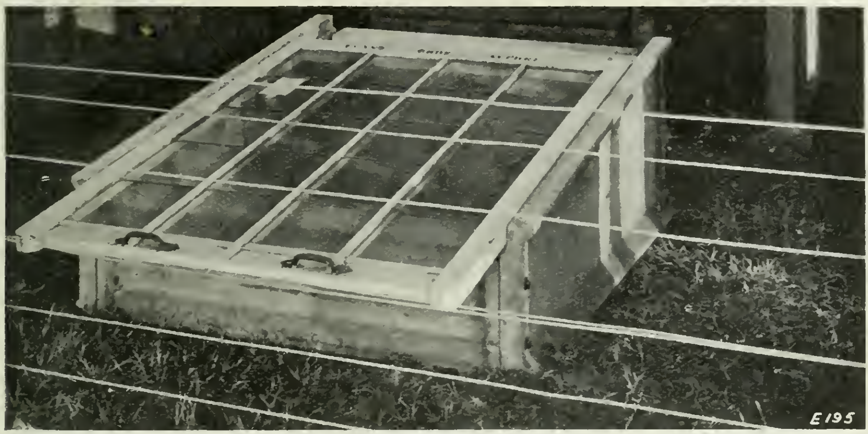


Fig. 5. Concrete Garden Frame.

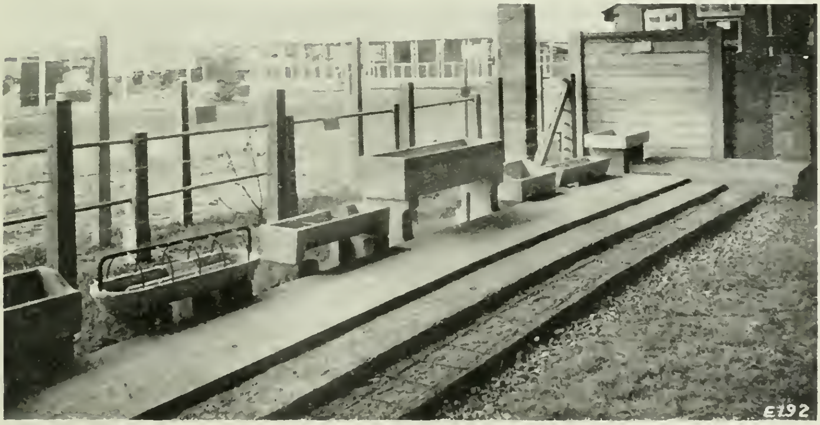


Fig. 6. Concrete Troughs and Hoarding, together with Section of Concrete Roadway showing Method of Construction.

The Northfleet Concrete Tile Company, of 50, Lime Street, London, E.C.3, exhibited their concrete tiles, which formed the roof of a cowhouse, the walls of which were built with Winget blocks.

Municipal authorities are turning their attention more and more to concrete as a substitute for cast iron for sewer pipes, water mains and gas mains, and there is no doubt that the older material is steadily giving place to the new. A very fine collection of concrete pipes was exhibited by the Stanton Hume Pipe Company, Ltd., of Stanton, near Nottingham. These pipes, which have a wonderfully finished appearance, are made by the centrifugal process, one of the latest developments of scientific practice as applied to concrete. The examples on view included pipes from 4 in. to 5 ft. internal diameter. Some of these may be seen in *Fig.* 7.

The Teign Valley Granite Co., Ltd., of Trusham, Chudleigh, Devon, have introduced a new and efficient principle in the construction of such small buildings as pigsties, fowl-houses and garages. This construction consists, essentially, of piers provided with slots into which are slipped grooved and tongued concrete "planks" which are not cemented together. The structures exhibited include two fowl-houses and a hoarding (the latter being seen in the background of *Fig.* 6). This firm also supplies concrete and wire fencing. *Fig.* 8 is an illustration of the pigsty exhibited by the same Company, and which clearly shows the principle.

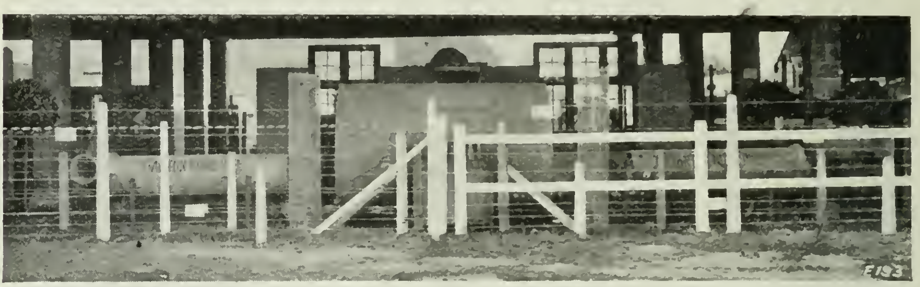


FIG. 7. REINFORCED CONCRETE PIPES MADE ON THE CENTRIFUGAL METHOD. THE PIPE IN THE CENTRE IS 5 FT. INTERNAL DIAMETER. AT EACH SIDE OF THIS CENTRAL PIPE PRE-WOVEN REINFORCEMENT FOR A SMALLER PIPE MAY BE SEEN.

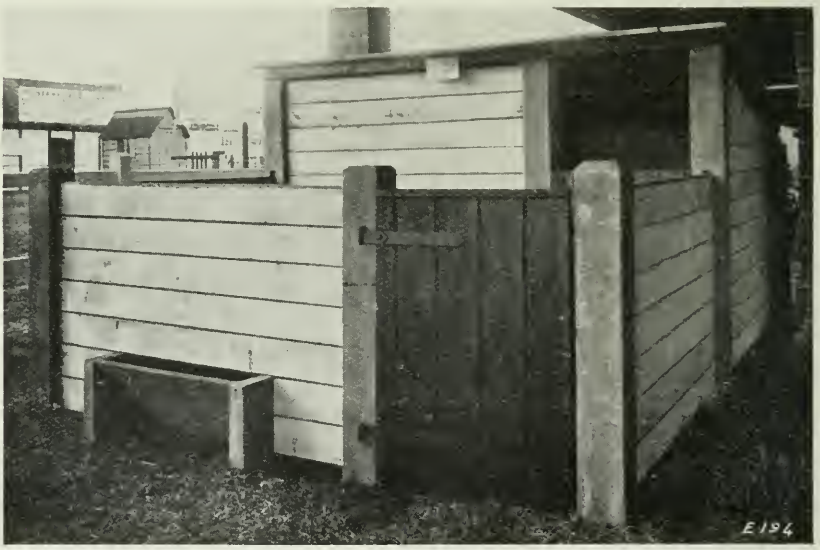


FIG. 8. CONCRETE PIGSTY CONSTRUCTED ON THE SIMPLE METHOD OF SLOTTED POSTS AND CONCRETE PLANKS.

The exhibits of the Wharf Lane Concrete Company, Ltd., of Ilminster, Somerset, were numerous and interesting. This firm is well known in the West of England and has specialised in farm and estate work, and in the imitation, in concrete, of any particular stone. Examples of the former consisted of a pair of cow-stalls, all the members of which were pre-cast, fence-posts for either wire or net fencing, cisterns, well tubes, posts for tennis court surrounds and drinking troughs with or without chamber for ball valve.

A most artistic example of the work of this firm consisted in a fine 4-light window frame illustrated in *Fig.* 9. This had every appearance of being stone, and by visitors was often mistaken for it. The finials and kerb seen in the same picture were of a similar nature.

Messrs. Winget, Ltd., of Grosvenor Gardens, S.W.1, exhibited a section of concrete walling made up of " Nonalike " blocks, one of their most recent productions. As the name indicates, the surface texture of the blocks is different in every case, no two being alike.

We have often drawn attention to the advantages of concrete construction to Municipal and County Authorities. One such example was seen in a new form of catch-pit for roadways, devised by Mr. W. Hopkins, consulting engineer, of Leonard Stanley, Gloucestershire, and adopted by the Gloucestershire County Council. Instead of the usual iron grid in the gutter with the catch-pit below, the latter is formed under the footpath, and the water enters it by means of four circular holes in the vertical face of the kerb. This is shown in *Fig* 10. An excellent example, too, of a concrete cowstall for small holdings and other farms was exhibited. This was erected *in situ* by Mr. Hopkins.

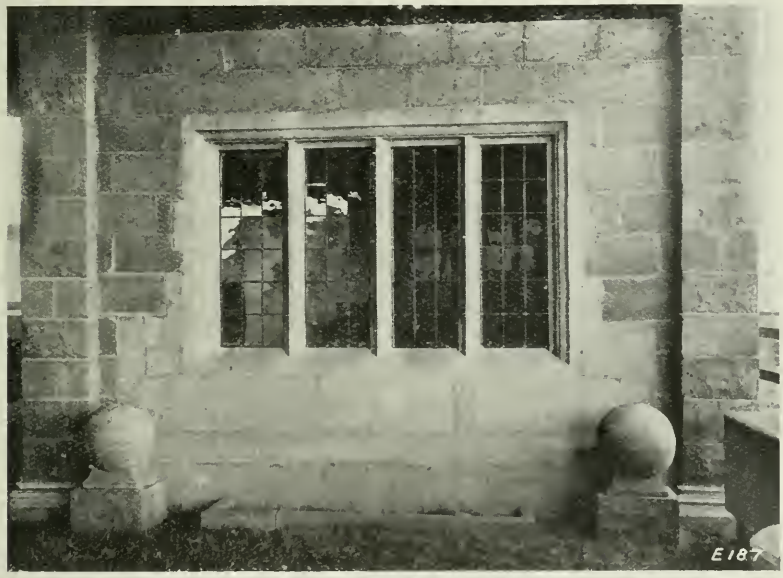


Fig. 9. Concrete Window Frame, Finials and Fire Kerb, made to Imitate a Local Stone.

The application of concrete for railway purposes was shown in a very striking manner by the exhibits which are the patents of Mr. W. Marriott, and were lent by the Midland and Great Northern Joint Railway Committee, of Melton Constable, Norfolk, whose engineer Mr. Marriott is. These consisted of a huge bracket signal post—probably the largest ever made in concrete, shown in *Fig.* 1—an ordinary signal post, also seen in *Fig.* 1, and two telegraph poles, one cruciform and the other triangular in section.

One of the latest of Mr. Marriott's patents is a sectional hollow telegraph or power pole. These poles are made in 4-ft. sections, and in this form are transported to the site and put together. The advantages are seen at a glance, the chief of which is, of course, facility in transport.

During the exhibition, demonstrations in the moulding of fence posts and other articles were given at frequent intervals, and the large number of visitors present on every occasion bore eloquent testimony to their interest in concrete work.

Near the Concrete Utilities Bureau Stand, Messrs. Tidnams, of Wisbech, exhibited various types of fencing posts which this firm has made one of its specialities. Another excellent exhibit was a reinforced concrete direction post, designed to meet the proposals of the Ministry of Transport. It is hexagonal in section, and although simple in design has a most pleasing appearance, owing to the admirable finish.

Other exhibits included a section of fencing, with gate and concrete gate posts and struts, especially devised for housing schemes, three wires being used ; two sections of field or boundary fencing of different designs, as used by the Great Western Railway Co., and two field gate posts carrying a 10-ft. gate ; samples of 4½-in. rock-faced building blocks, and a corner manger with rim and lip, and provided with bolt-holes in the sides and a drainage hole in the bottom.

Messrs. Henry Wilde, Ltd., of 66, Victoria Street, Westminster, whose concrete power mixers were exhibited at the Royal Show last year, showed their various hand machines and moulds for the manufacture of concrete products. Of especial interest to the estate owner and farmer were the Block Moulds, Brick Machines and Fence Post moulds. The Agricultural Pipe Machine, making per day 1,000 pipes each one foot long, and of various diameters ranging from 1½ in. to 6 in., also aroused great interest. The Hand Mixer shown at this stand appeared to be a very capable machine, and its operation interested many of the onlookers. Among the concrete products which can be made on the machines and moulds supplied by this firm are Roofing Tiles, Floor Tiles, Flower Pots and Silo Blocks.

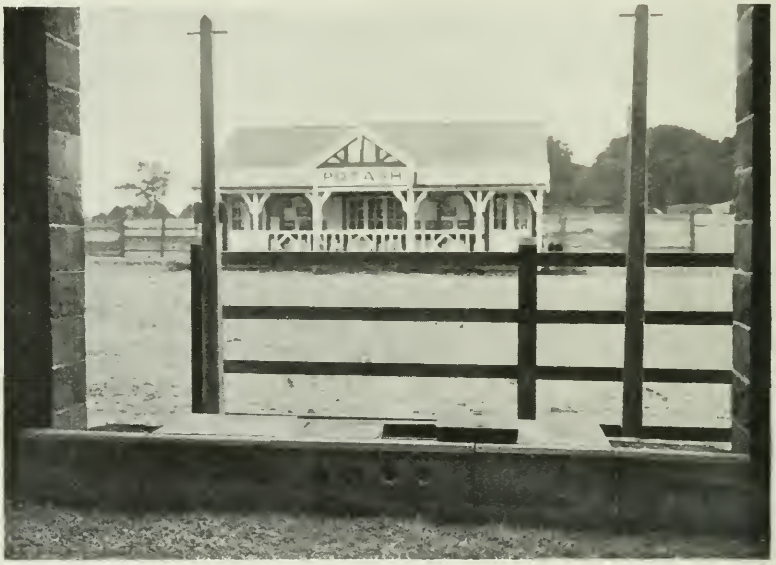


Fig. 10. This Illustration shows the Holes in the Vertical Face of a Concrete Kerb leading to Catchpit under the Footpath. The Cover of the Catchpit has been removed.
Two Concrete Clothes-Line Posts are also seen in this Picture

Adjacent to the former was the stand of the " Manelite " Patent Concrete Machinery Co., Ltd., of Petra Place, Poole Hill, Bournemouth. This firm exhibited their patent Hydraulic and Hand Power Concrete Block Machines. The Hydraulic Machine is claimed to be the fastest Concrete Block-making machine in the world, and it is stated that recently two operators manufactured 150 yards super of finished blocks in nine hours.

Demonstrations on the working of their respective machines were given at frequent intervals by both the above firms and attracted a large number of interested spectators.

REINFORCED CONCRETE ON THE CONTINENT.

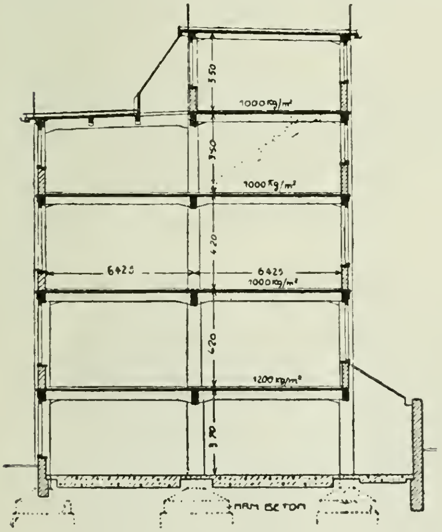
Below we reproduce some illustrations, together with short particulars, of some examples of reinforced concrete work in Bohemia and Italy: Our information and illustrations regarding the Grain Silo and the Printing Works are from "Le Béton Armé," Brussels, whilst the particulars and illustrations of the Bridge are abstracted from "Il Cemento."—Ed.

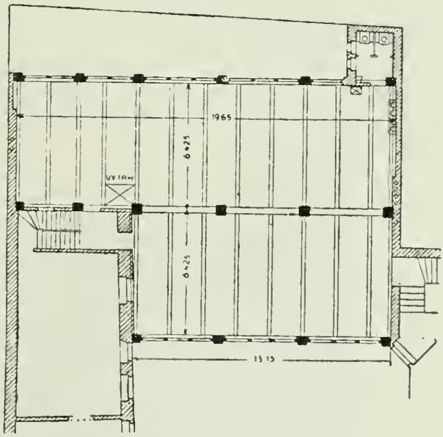
TWO BOHEMIAN STRUCTURES IN REINFORCED CONCRETE.

Considerable interest attaches to two Bohemian structures in reinforced concrete, the first being an annexe to a printing establishment and a silo at Prague.

The floors in a printing works are required to carry very heavy loads as well as massive and rapidly running machines, and the difficulties of design were increased by the fact that the whole of the daylight was derived from two small courts.

The building is constructed throughout of reinforced concrete, the floors being carried on three rows of pillars with girders and beams on the Hennebique system, the first floor being designed to carry a load of 240 lb. per sq. ft. and the remaining floor 200 lb. per sq. ft. By this means the maximum of





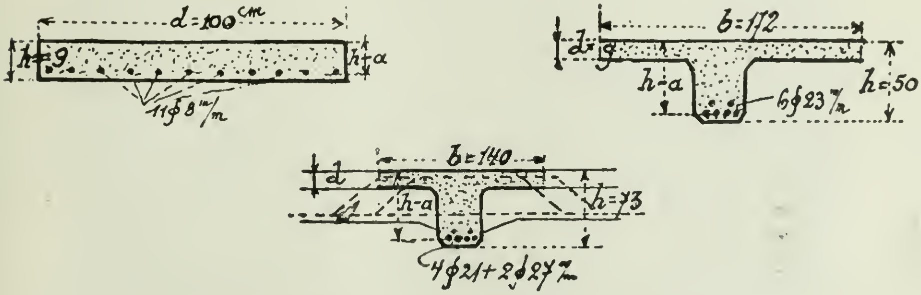
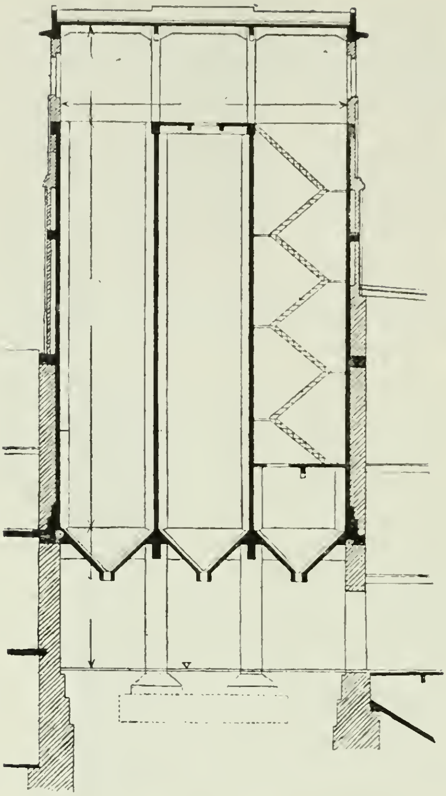
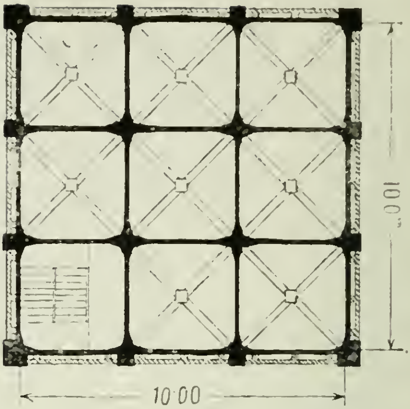


Fig. 1. Transverse Section; Fig. 2. Ground Floor; Fig. 3. Details.
Printing Works, Prague.





daylight was obtained in the interior. When tested with a load of 360 lbs. per sq. ft. the maximum deflection was only 0·036 in., and even this disappeared when the load was removed.

The silo was designed to accommodate 100 wagonloads of grain, and is the first reinforced concrete silo to be built in Bohemia, and has rapidly proved itself free from the disadvantages of wooden silos. It consists of nine compartments, of which eight are for the grain, whilst the last is for the lift.

Figs. 4, 5 6. Silos at Prague.

As the climate is very severe, the exterior of the structure is protected by masonry 6 in. thick, a cavity being left between the masonry and the concrete, so as to ensure an equable temperature in the interior of the silo.

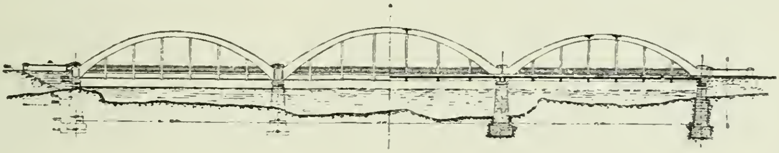
The foundation consists of 111 piles of reinforced concrete 29 ft. by 10 in. by 10 in. reinforced with four rods each 1 in. diameter. The ratio of cement to aggregate was 1 : 3. The piles penetrated through a considerable thickness of bad ground and for a depth of 12 ft. into a good subsoil.

The general design and dimensions (in metres) of both these structures are shown in the accompanying illustrations. In both cases the work was carried out by V. Vlcek, Prague.

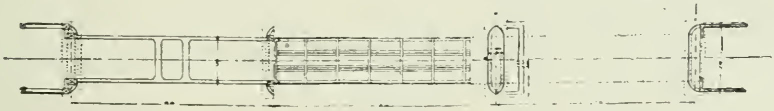
THE ARDENHO BRIDGE.

Bridges built of reinforced concrete of the bowstring type, in which the roadway is suspended from two or more arches, have the great advantage of offering a maximum space for the passage of the water. This is specially important in bridges over rivers subject to sudden floods.

The new Ardenho Bridge, which was built over the Masino—a typical mountain torrent—last year, is 260 ft. long, 17 ft. wide, and consists of two spans each of 83 ft. and a central span of 93 ft. It has been designed for a uniform load of 90 lb. per sq. ft. and for the passage of two rows of vehicles each weighing 6 tons.



Plan Perspective. Longitudinal Section.



Plan. View from below. Columns.

The abutments and river piers are of masonry on mass concrete, the superstructure being wholly of reinforced concrete, the pillars faced with local granite.

In order to avoid tension cracks, the ties were not concreted until after removal of the centering, when the steel was ready in tension. The uprights or hangars were only concreted after the completion of the arches and roadway. The couplers of the arches are propped by two cross-pieces, and the appearance of the bridge is improved by an iron parapet.

The tension members are 16 sq. in. in section on the central traverse and 14 sq. in. in section on the outer traverses. About 45 tons of steel and 90 tons of cement were used in the construction of the bridge, the erection of which required two months. The general work was carried out under the supervision of Enrico Dacorsi, chief of the Chemical Bureau of Sondrio, the foundations and pillar-work were constructed by the Entreprise Pedazzi, of Morbegno, and the superstructure by the Société Anonyme Italienne Ferrobeton de Rome.

It may be of interest to recall the fact that two bridges of the same general type are to be found at Purfleet and at Tilbury. Five similar bridges have also been built recently at Newport, as approaches to a series of coal-tip jetties constructed for the Alexandra Docks and Railway Company.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete, the articles being prepared by Messrs. Andrews and Beaumont, Patent Agents, of 204–6 Bank Chambers, 29 Southampton Buildings, W.C.2. The last article appeared in our issue of April 1921.—Ed.

Reinforced Concrete.—*No.* 153,991. *W. Marriott, Sheringham, Norfolk. September* 1, 1919.—A metallic box-like reinforcement comprises main rods or tubes *a* (*Fig.* 1), transverse bars *b*, side undulatory rods *c* engaging over the ends of the bars *b*, and top and bottom undulatory rods *d*, all the rods and bars being welded at their points of contact. The main and other bars may be in pairs as shown in the modification in *Fig*. 4. The invention is applicable to girders and beams, columns, piles, and like constructions.

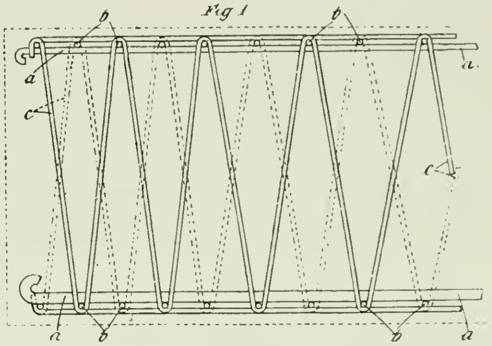


Fig 1

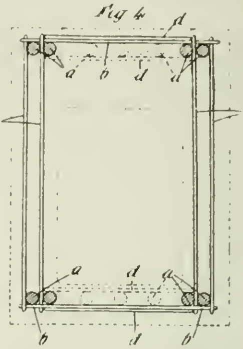


Fig 4

Floors.—*No.* 155,043. *A. E. Marshall,* 27 *Nightingale Lane, Hornsey, London. September* 18, 1919.—In floors consisting of precast reinforced concrete beams laid side by side on joists, the beams are coffered on the underside and the flanges *1* are sloped in the inner faces to the shape shown in *Fig*. 5 and are grooved at the side to form between adjacent beams an open-mouthed channel *17* to receive grouting. Rods *22*, *23* may be placed in the channels and may support wires not shown to carry ceiling rods or other flat ceiling *24*. Specifications 2191/06 and 6504/06 are referred to.

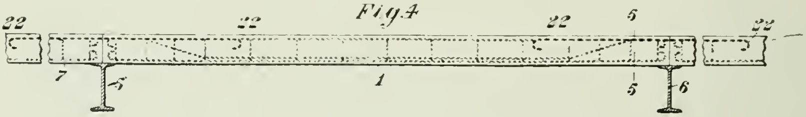


Fig.4.

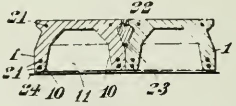


Fig.5.

Walls.—*No.* 154,091. *J. D. Roots,* 58 *Avonmore Road, West Kensington, London. January* 2, 1920.—Concrete slabs *A* are supported by reinforced concrete posts moulded *in situ* by means of moulds *B*, *B*^{1}, *E*, *E*^{1}. The parts of the moulds are held in position during filling by bolts *C*. The ends of the slabs are embedded in the concrete and during the moulding are held by flanges *B*^{2} on the moulds. The bolts pass through battens *D* on to which the reinforcement *F* is tacked, and which may serve to support internal boarding *M* or laths and plaster. Double walls are similarly constructed.

Fig. 2

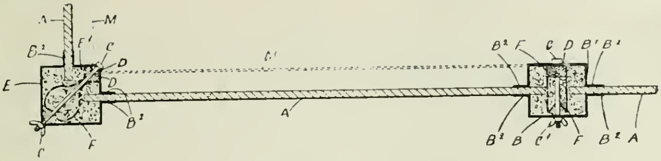
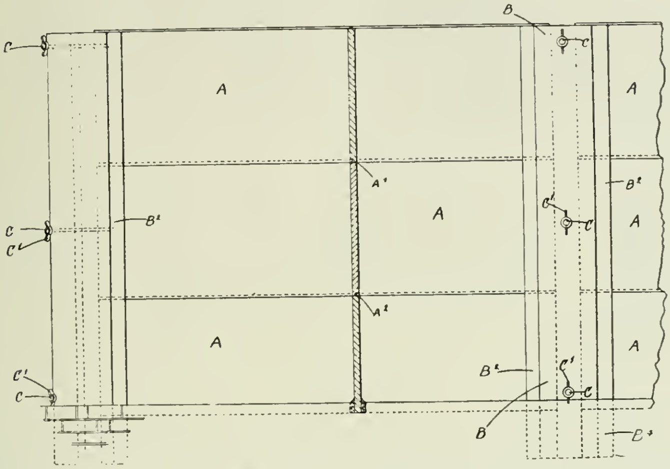


Fig. 1



Walls.—*No.* 154,392. *M. M. Smith, Harpsden Wood House, Harpsden, Henley-on-Thames. September* 26, 1919.—A damp-proof concrete wall comprises flexible waterproof sheeting B^1 (*Fig.* 1), which is suspended in the mould C in horizontal or vertical strips, the edges of which overlap, and metal ties D placed to bridge the sheets without perforating them. Corner and intermediate piers may consist of two thicknesses of bricks laid to form toothed edges and with damp-proof material between them and projecting as shown. Or the piers may consist of precast inner and outer posts E (*Fig.* 3), tied together by straps F and with grooves E^1 to key with the concrete wall. The bases of the posts may be embedded in concrete cast in cylindrical holes in the ground and the first course in the wall may be formed as an arch J either *in situ* or precast.

FIG 1

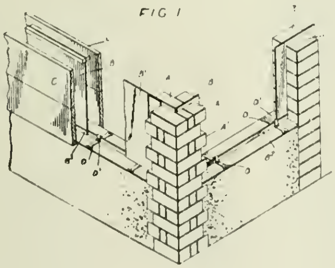
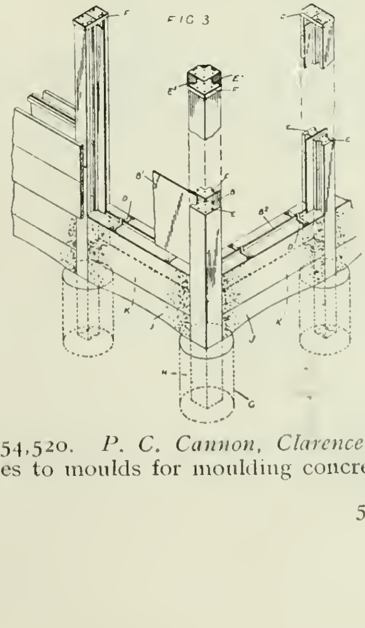


FIG 3



Moulding Concrete Blocks, etc.—*No.* 154,520. *P. C. Cannon, Clarence Street, Wolverhampton. February* 27, 1920.—Relates to moulds for moulding concrete and like blocks, pipes, short posts, beams, girders, etc. The mould is made in two L-shaped sections as shown in *Fig.* 2, secured together by an end plate *d* which is formed either in two parts *h*, *h*¹ hinged together along a diagonal, or as a spring or buckled plate, as shown in *Fig.* 3, so that the sections may be slightly separated, as shown in dotted lines in *Fig.* 4 for the removal of the block, etc. The opposite end of the mould is provided with a lid or cover having a central aperture *k* fitted with a plug for the removal of moisture, and taper flanges *l* engaging with corresponding parts on the sections. The cover is secured in the closed position by lugs *n* engaging with slots in the sections and carried by rotary spindles *o* on the lid provided with handles *p*. The mould shown is adapted for the moulding of concrete building-blocks in a centrifugal machine, the mould being rotated for, say, four minutes at 450 revolutions per minute, after which the article is removed, steamed, and dried.

Fig. 1.

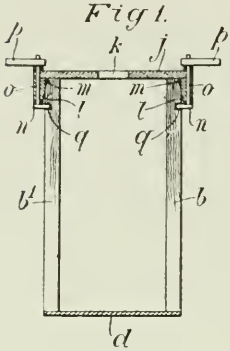
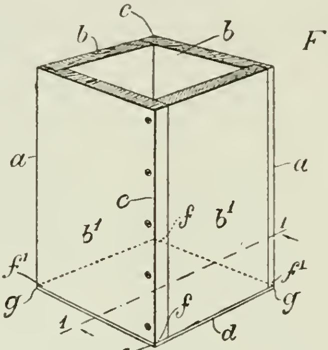


Fig. 2.



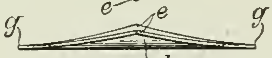
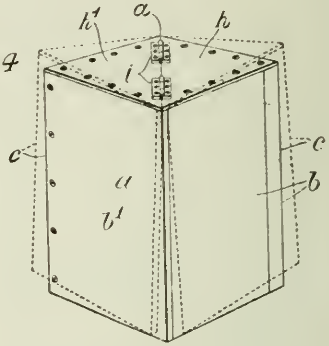


Fig. 3.

Fig. 4



Fireproof Flooring.—*No.* 155,072. *T. R. McDowall,* 14 *Upstall Street, Myatts Park, London. October* 10, 1919.—Hollow fireproof flooring-blocks, which are supported between or on joists by tie-rods, are provided with improved interlocking means comprising semicircular tongues and grooves *10*, *11*. The reinforcing tie-rods, which are at right-angles to the supporting tie-rods, may be in the form of flat strips engaging registering slots *16a* in the blocks. The tie-rods are secured to angle irons secured to the girders or to hangers which span the girders on opposite sides, or to separate hangers *21* (*Fig.* 6), connected to a slotted plate *22*.

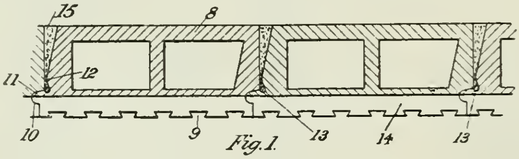


Fig. 1.

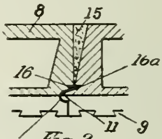


Fig. 2.

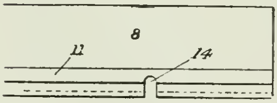


Fig. 3.

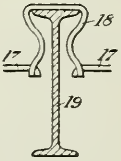


Fig. 4.

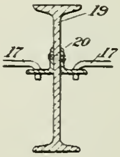


Fig. 5

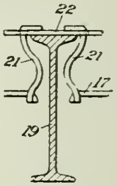


Fig. 6

Moulding Concrete and like Blocks.—*No.* 157,510. *E. L. Warren and W. J. Parker, Manor Works, High Road, Byfleet, Surrey. October* 2, 1919.—A machine for making concrete or breeze blocks comprises a timber framework *a* supporting a table *b* from which depends moulds *c*, constructed of timber and provided with sheet metal linings *d*, and a false bottom *g* resting on a framework j^1, *j*, which is raised to eject the blocks by a cord or chain *n* passing around a pulley *m* on the framework and connected to a rotary drum *q* and to the framework of the mould. The cord may be attached at *o* or o^1, according to whether it is desired to make hollow blocks by means of a core *e* or to make solid blocks. The core *e* may be tubular and of sheet-metal, or of wood shod with sheet-metal as shown. The mould is provided with loose end-pieces with detachable metal facings to form keys and grooves in the blocks, and may be adapted to make concrete or breeze blocks of the shape and size of the ordinary stock brick.

Fig 1.

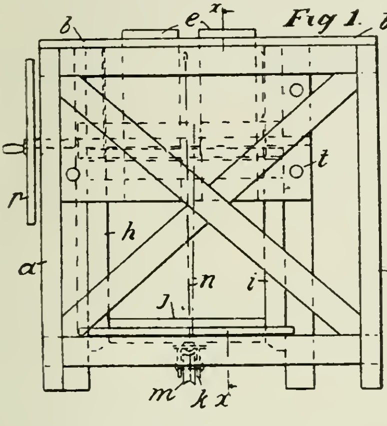
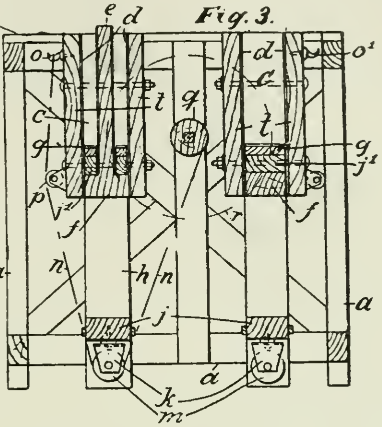
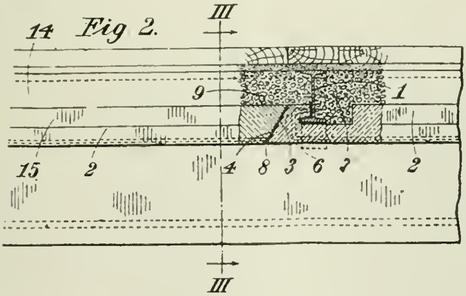


Fig. 3.



Floors.—*No.* 158,299. *W. Green,* 14 *Fielding Road, West Kensington, London. September* 29, 1919. A floor or ceiling consists of flat tiles *2* having parallel bevelled ends *3*, *4* and an undercut groove *7* in the top face forming a hook by which the tiles are suspended from the cross beams *1*. The upper face may have a single rib *15* of dovetail section, and the tiles may have reinforcements *12* preferably extending into the hook. Concrete is filled in above the tiles, and may be finished with cement *10* and wooden or other flooring *11*.

Fig 2.



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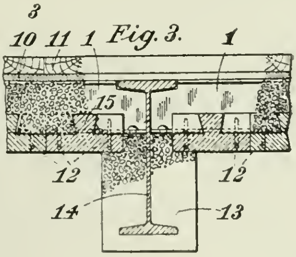

Reinforced Concrete Pipes.—*No.* 158,588. *Sir J. P. Fitzpatrick, Lincoln Chambers, Portsmouth Street, London, and B. Bradley,* 2, *Carlton Bank, Harpenden, Hertfordshire. July* 24, 1919.—In a method of forming reinforced concrete pipes with projecting portions thereon for connection to branches, the circumferential reinforcements in the neighbourhood of the projecting portion are associated with annular reinforcements *3*, and are carried outwardly to act as longitudinal reinforcements *5* of the projecting portion. The ends *1*ª of certain of the longitudinal reinforcements *1* of the pipe may also be carried outwardly, and their ends as well as the ends of the portions *5* are attached to a terminal ring *7*. The projecting portion is provided with circumferential reinforcements *6*. A mould for the construction of the pipe is shown in *Fig.* 4. A cover-plate *10* with a groove *11* is provided to form the projecting portion. The mould is provided with holes and cover-plates therefor of the size of the largest projecting portion required, the grooves *11* being made of the thickness necessary to form the size required. A block *12* is secured to the cover-plate forming a core for the hole required and is preferably balanced by a counter-weight *14*.

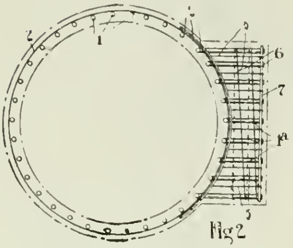

Fig 2

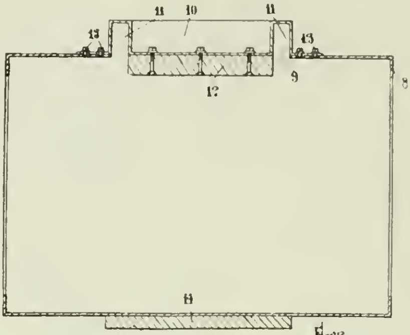

Fig 3

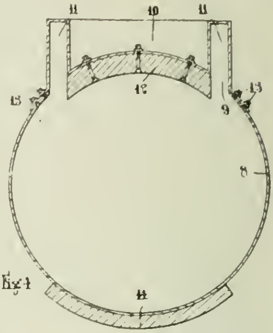

Fig 4

Reinforced Concrete Floors.—*No.* 158,703. *W. J. Mellersh-Jackson,* 28 *Southampton Buildings, London. November* 11, 1919.—The flooring is constructed on girders, but with longitudinal and transverse ribs *1*, *2* respectively on the underside in which the reinforcements *4*, *5* (*Fig.* 2) are embedded. In the case of an oblong floor, the longitudinal ribs *1* are deeper than the transverse ribs *2*. The depths of the longitudinal and transverse ribs and consequently the distances between the respective rods and the neutral plane of the floor are designed with regard to the respective spans. The flooring is supported on columns which may or may not be provided with panels on the top. A ceiling may be attached to the longitudinal ribs, thereby leaving spaces between it and the transverse ribs in which pipes or conduits may be placed. The flooring may be cast by means of removable forms described in Specification 123,696. Specification 158,397 also is referred to.

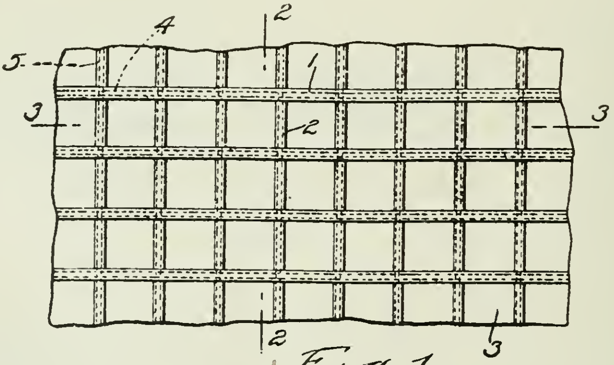

Fig 1.

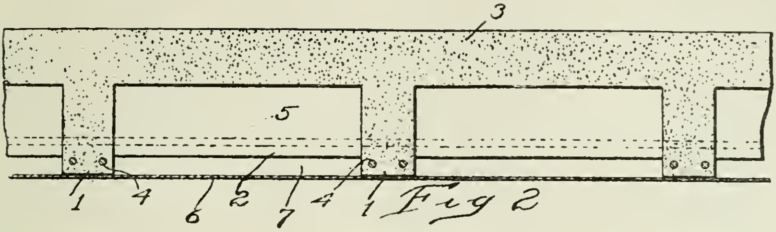

Fig 2

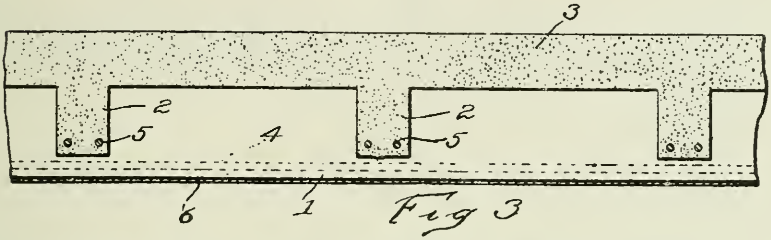

Fig 3

Laying Blocks.—*No.* 158,973. *W. H. Smith, The Bungalow, Imber Court, Thames Ditton, Surrey. November* 11, 1919.—To facilitate the laying of blocks, particularly those of the triangular type described in Specification 140,312, a templet is employed on each side of the wall and comprises a board or braced frame *a* (*Fig.* 2) and spaced ganging-strips a^1 to determine the pitch of the blocks. The blocks are laid in mortar with their upper faces flush with the top edges of the templet. Hinged clips may be swung into the cavities of the blocks to hold them until the mortar has set. The templet *a* may be braced by a frame a^2, a^3 hinged at d^3 to saddles *d* which are clamped and adjusted by screws d^1, d^2 and carry brackets *e* for levelling-screws a^4. The back templet is held by a swing bolt a^5. In the modification shown in *Fig.* 3, the templet is supported on and guided by posts *f* which may be adjustable vertically and horizontally. Pins *g* engage holes f^1, *h* to hold the templet in correct position.

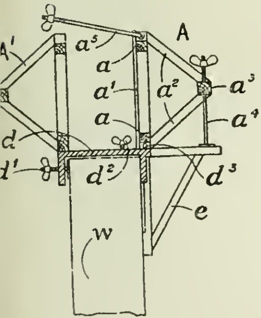

Fig. 2

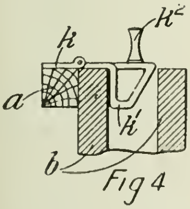

Fig 4

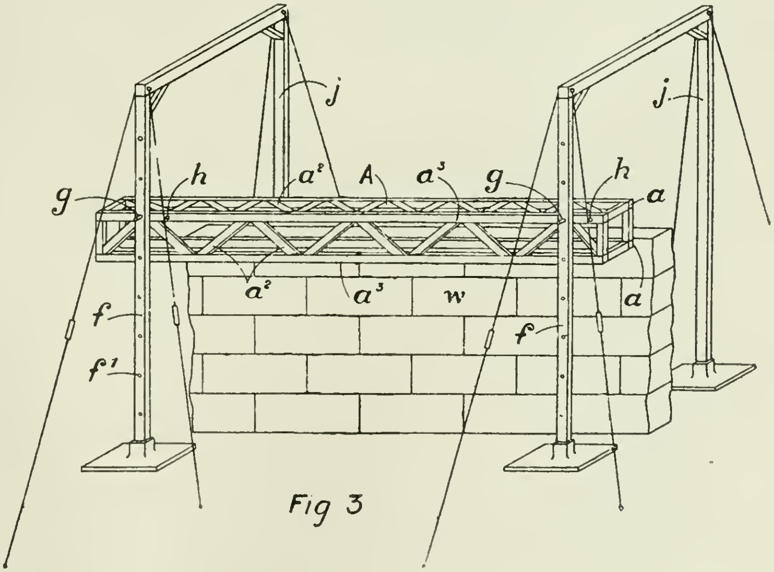

Fig 3

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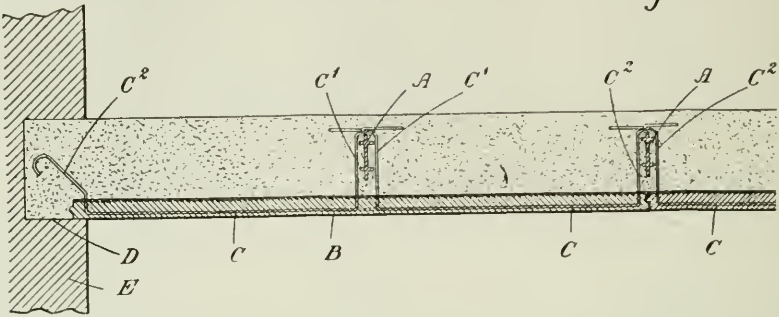
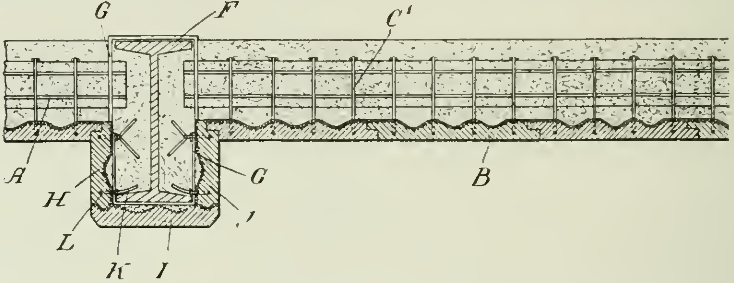
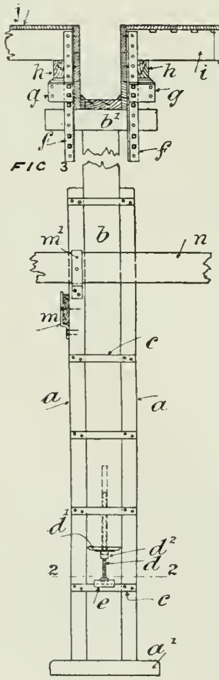


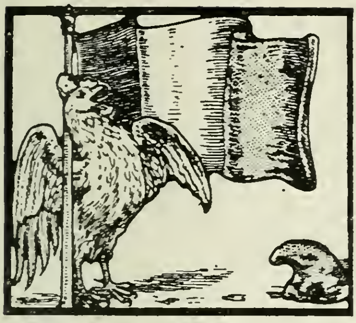
Fig. 2



Reinforced Concrete Floors.—*No.* 159,256. *A. M. Bowley,* 1 *Tudor Street, London. November* 3, 1919.—A floor is formed by suspending concrete slabs *B* from transverse beams *A* by twisting together the projecting ends C^1 of the slab reinforcements *C*, the ends being left extending, and filling in concrete over the slabs and beams. The beams rest at their ends on ledges or in recesses in the walls, or are supported by stirrups *G* from girders *F*. The lower parts of the girders are enclosed by slabs *H, I, J* having reinforcing bars with the projecting ends pointing inwards, and alternate ends of these bars in the side slabs are twisted with those of the bottom slab, the remainder projecting from the bottom slab being bent to engage the girder. The meeting edges of the floor and beam slabs may interlock, and the ceiling faces may be smooth or corrugated or rough cast. Specifications 16700/03, 2597/08, 4116/08, and 113,669 are referred to.



Centering for Floors and Ceilings.—*No.* 160,329. *B. Green,* 40 *Mount Street, Levenshulme, Manchester. January* 17, 1919.—Beam moulds are formed of adjustable frames *f* carried by a cross bearer b^1 which is carried by an upright *b* adjustable by means of a screw *d* in a frame *a*. The frames also carry side brackets *g* for the floor bearers *h*, which carry the adjustable cross beams *i* so that the distances between the beams may be varied. The upright frames *a* are connected by laths *m, n*.



A FISH-FREEZING PLANT ON THE ISLAND OF ST. PIERRE

FOR THE FRENCH GOVERNMENT

In an article in the " Contract Record " Mr. H. C. Paddock gives some particulars and illustrations of the erection of the above plant. The work presented some difficulties in regard to erection, and for that reason it may interest readers to have some information regarding its execution.—ED.

THE Island of St. Pierre is situated about twelve miles south of Newfoundland. The fish-freezing plant is approximately 140 ft. by 85 ft., six storeys in height, with an adjoining power house, 75 ft. by 84 ft., three storeys in height. The floor construction is of the flat slab type with a granolithic finish, and is designed for a uniform live load of 200 lb. per square foot. The 8 in. concrete exterior walls, poured monolithic with the columns, are finished with a coat of cement wash. For insulation, a continuous envelope of varying thicknesses of sheet cork is placed on top of the roof and extends down on the inside of the exterior walls and over the second floor slab. The construction, however, outside of the difficulties encountered in the erection of the building, has nothing unusual about it.

This plant is probably one of the largest fish-freezing establishments ever built, having a capacity of 100 tons per day. The fish are washed and panned on the dock and carried by elevators to the sharp freezers on the sixth floor. These freezers are operated on the direct expansion system at a temperature of 25 degrees below zero Fahrenheit. After glazing and boxing, the fish are delivered by spiral chute to the various floors for storage, or to the dock for shipment. The various storage floors have a total capacity of 3,000 tons, designed for a zero degree temperature.

The building project was carried out for the Republic of France by the Turner Construction Co., of New York City, under the direction of Ophuls, Hill & McCreery, refrigerating engineers, also of New York city.

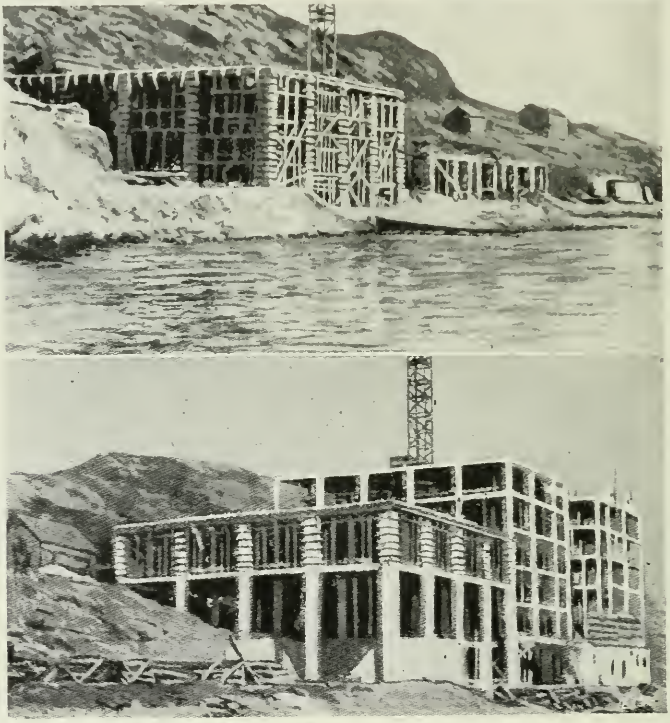
A preliminary investigation of the site showed that no materials could be obtained locally except sand and gravel. Of these there was apparently a good supply on the south-easterly point of the island. It was necessary, however, to ship all equipment such as boilers, engines, mixers and tools from New York, while cement was brought from Montreal, lumber from New Brunswick, and steel from Pittsburgh.

The shipping of materials was a problem in itself, requiring the services of an expediter with an office at North Sydney, Cape Breton, to attend to the complicated matter of trans-shipment. The only regular line of communication with St. Pierre was by a French steamer of 450 tons capacity, which ran to North Sydney once a week, with monthly trips to Halifax. From about December to May, the North Sydney harbour was icebound, and Halifax became the regular port. With this limited means of transportation it was difficult to maintain a pre-arranged schedule of delivery, and it required considerable ingenuity on the part of the expediter to stow away a few additional tons of material on a vessel already loaded to capacity.

Building operations were begun during the fishing season, so that local labour could not be obtained at first, but later a good supply was available, full advantage of which was taken.

The excavation turned out to be one of the surprises of the undertaking. The total amount of rock to be removed was not great, about 1,100 yards, but the extreme hardness was the cause of delaying completion of the excavation about four weeks. The rock formation of the island is quartz porphyry, an igneous rock as hard as flint.

At the beginning there seemed to be a ready supply of beach sand and gravel about three miles from the building site, but a severe storm carried most of it away, leaving nothing but a perplexing situation. It was thought advisable to purchase a rock pulveriser which could be used in case a suitable supply could not be found, but through the aid of a fisherman a large deposit of sand was found on the south shore of the island about three and a half miles away. This sand was covered with several feet of large stones and gravel, which, of course, had to be stripped. The loading of sand was interrupted several times because the sand pits were covered with stones and débris by severe storms which swept over the bar separating the ocean from the sand supply.



Two Progress Views taken within Seven Weeks of Each Other.

Severe Fire Destroys Concrete.

In December, 1919, when the building was within two weeks of final completion, one of the worst blizzards in many years swept the island, burying everything in snow, in many places 20 ft. deep, so that all the men were withdrawn until spring, with the exception of a watchman. During this time of inactivity a fire of extreme severity occurred in the first storey, covering an area of some 4,500 sq. ft. This portion was enclosed entirely except for the hatch for the concrete hoist and a small opening in a wall left for construction purposes. The French Government had stored in this section a large amount of material to be used in insulating the building, as well as considerable lumber and miscellaneous material for construction work. In some unaccountable way this inflammable material caught fire and burned fiercely for fifteen hours, even though water was poured on it continuously.

RECONSTRUCTION METHODS.

A careful investigation showed that it was necessary to remove the entire second floor, which had been subjected to the fire, as well as the fire-proofing of all columns Upon removing the floor it was found that the 8¼ in. slab was calcined nearly the entire thickness, and after a small hole had been made, a stroke from a sledge would cause cracks to shoot out in all directions, making it necessary to be extremely careful with the shoring. The damaged portions of the columns were removed and reinforced concrete shells were formed about the columns, poured practically monolithic with the new floor. The concrete walls and partitions which were not bearing walls and which had been damaged were sprayed with water for several days for the purpose of re-hardening them. A cement wash was then applied.

The lateral expansion of the second floor caused several bad cracks in stair and elevator shafts, these walls evidently acting as vertical girders, being held rigidly top and bottom with a horizontal load at the second floor level. This building, as is customary in refrigerating buildings, had the outer wall separated from the columns and floor of the structure by the cork insulation. In many cases the iron ties between the outer shell and the columns were pushed or pulled out of the concrete walls and columns as a result of the expansion and subsequent contraction.

The roof and top floor at the hoist tower had been filled in. This prevented the shaft from acting as a flue as it otherwise would have done, forcing the flames through the first storey doors and windows, causing considerable damage by smoke and greasy soot settling over the entire building. This was removed by brushing dry, followed by several applications of washing powder and water.

MEMORANDA.

Reinforced Concrete Sewer Ventilating Tubes.—The annual report of the New South Wales Department of Public Works states that since the price of iron increased attention has been given by the Department to a cheaper and more durable form of construction for sewer ventilating tubes. At the suggestion of the Department, the State Monier Pipe Works designed and manufactured tubes of reinforced concrete for this purpose, and these are now in use in place of iron ventilators. The report states that " these tubes at present prices are cheaper, and when erected are practically indestructible, and cost nothing for maintenance, whereas the iron tubes required frequent painting ; also, even if properly coated externally, corrosion is soon set up internally in iron tubes by the action of the sewer gases and moisture, necessitating their periodical renewal."

The Cement Gun.—In the course of a paper read before the members of the Surveyors' Institution on the occasion of the visit of the Institution to Norwich last month, Mr. Arthur E. Collins (City Engineer, Norwich) said the cement gun that had been used for external plastering on the Norwich housing scheme had given very satisfactory results. He had found that the high pressure and velocity with which the materials were forced against the wall surface resulted in an extremely dense coating being obtained, and that with ordinary Portland cement the plastering was so hard after two days that it would withstand hammer blows as well as similar plastering done by hand would after it had been deposited for a week. By the use of the gun the exteriors of two cottages could be plastered per day. His experience was that if the sand were too coarse, or if too much of it were used, the coarse material or the excess of sand would be rejected by the machine, and the rejected material, which lay at the foot of the wall, could be taken up and re-used. It was a peculiarity that the rejected sand, although each particle had almost certainly been coated with cement when it reached the nozzle, was entirely free from cement.

RESEARCH ON CONCRETE IN AMERICA.

At the twenty-fourth annual meeting of the American Society for Testing Materials, held at Astbury Park, New Jersey, on June 21–24 last, a large number of papers were read and discussed dealing with a variety of materials. The following are abstracts of the papers dealing with subjects of interest to reinforced concrete engineers :—

WEAR TESTS OF CONCRETE.

By Duff A. Abrams.

In view of the increasing interest taken in concrete as a road surfacing material this paper, by such a well-known authority, serves a useful purpose if only by emphasising the principles which have frequently been put forward in this Journal for obtaining successful results, namely, the use of good concrete carefully made. The method of testing the samples was a novel one. A ring of ten separate blocks, 8 in. square by 5 in. deep, was fixed on the inside of a cylinder containing a charge of iron balls weighing 200 lb. The cylinder was then rotated for one hour, during which time 1,800 revolutions were made, the samples being subjected to the tumbling action of the iron balls. Altogether over 7,000 test pieces were subjected to this test. The general conclusions drawn from the tests by the author are as follows :—The factors that make for strong concrete also produce concrete of good wearing qualities, and increasing the quantity of cement decreases the wear. An increase in the quantity of water decreases the wearing qualities. Up to certain limits, the coarser the aggregate the lower the wear, but the quality of fine or coarse aggregate produced less effect on the wearing qualities of the concrete than is commonly supposed. The wearing qualities are materially increased by increased mixing, and also with the age of the concrete. The wear of the concrete was not sensibly increased by the use of hydrated lime or other admixtures up to 20 per cent. of the volume of cement. The tests also demonstrated the importance of curing concrete for a time in a moist condition if the best results are to be obtained.

THE EFFECT OF RODDING CONCRETE.

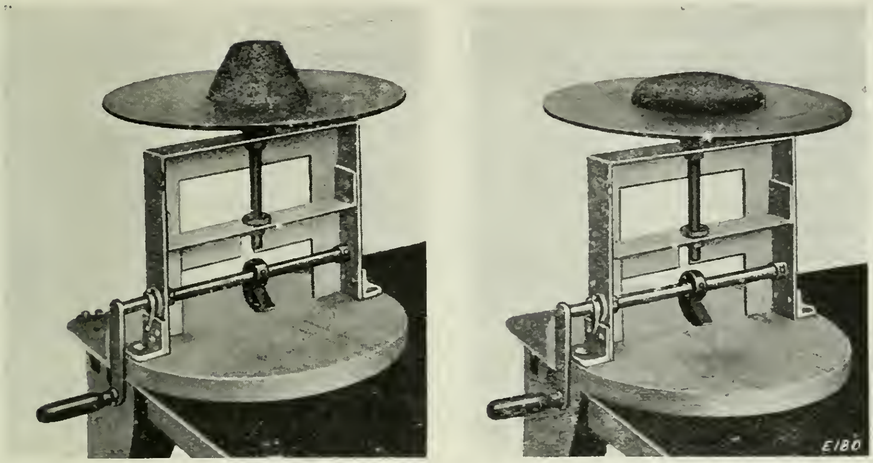
By F. E. Giesecke.

This paper embodies the results of further tests on the effect of rodding concrete which have been carried out by the author at the University of Texas. The tests were of an exhaustive character, comprising some forty-eight different mixes, and the tabulated results show that the increase of strength due to rodding is greater for lean than for rich mixes ; that it is usually greater for wet than for dry mixes, and that the rate of increase of the modulus of elasticity due to rodding is about the same as the rate of increase in compressive strength due to rodding, although with rich mixes it is slightly less. It is shown that the increased compressive strength of samples rodded six times over samples rodded once only ranges from 138 per cent. to 8 per cent. (A rodding consists of pushing a rod into the concrete 25 times and allowing all the water that comes to the surface to escape.)

SETTING TESTS ON CONCRETE.

By Watson Davis.

The author of this paper described a new method of determining the time of set of concrete in building operations by means of a " flow table " devised by the United States Bureau of Standards, to indicate the time when the concrete ceases to flow and becomes a non-plastic solid. As the author pointed out, a simple method of deciding the earliest time at which a concrete floor could be finished off, or forms struck on a building, would be of great value in constructional work. The method advocated, the " flow table," consists of a rigid frame with a top mounted on a vertical shaft so that it can be jolted or allowed to drop any fixed distance by means of a rotated cam. A test piece of concrete in the form of a disc or cone is placed on the table top and jolted a given number of times, its increasing diameter being measured by calipers. The diameter after jolting divided by the original diameter and multiplied by 100 gives a figure which is the criterion of consistency or flowability. In the test for the time of set, the rate of decrease of flowability is measured as follows :



Small Flow Table before and after a Test for Flowability.

A number of discs of concrete are moulded and tested in succession at stated intervals. At the beginning of the test the discs are jolted at intervals of one hour, but as the flow decreases the intervals between the joltings are decreased. The time of set of the concrete is considered to be the point when the concrete ceases to flow, and in practice a flow of 105 as determined by the above method is considered to be the point of " no flow." As an illustration of the practical application of the flow table, the author states that by its use in the construction of a concrete floor it was found that a 1 : 2 topping could be wood-floated when it had a flowability of 190, and finished with a steel trowel when it had a flowability of 140.

A COMPARISON OF THE SLUMP TEST AND THE FLOW TABLE.

By W. L. Schwalbe.

In this paper the author gives the results of investigations into the comparative results of the slump test and the flow table in the measurement of the consistency of concrete, from which he has come to the conclusion that the flow table is the more satisfactory method of the two. The flow table used was of the same type as that described in the previous paper, the cam on which allowed for a drop of ½ in. In general, it was found that relative consistencies are more truly indicated by the flow table for a greater range of consistencies than by the slump test, especially in the case of drier concretes and coarser mixes ; that the divergence from the average for a wide range of consistencies under different conditions is relatively small for the flow table ; and that for the manufacture of concrete under practical conditions the flow table is the more satisfactory for measuring consistency.

MEMORANDUM.

Effect of Vibration in Moulding Concrete.—The effect on the strength of concrete blocks of vibration during the process of moulding has been investigated at the National Physical Laboratory, Teddington, at the request of the Civil Engineering Division of the Ministry of Transport, and the results of the tests are briefly set out in the Report of the Laboratory for the year 1920, just published. The test pieces were divided into two sets consisting of twelve blocks, six of which in each case were made in the usual way and six were vibrated during the process of moulding for about thirty seconds by a pneumatic hammer applied to the outside of the mould. After twenty-eight days the blocks were tested for compressive strength, and it was found that in the first set of tests the strength of the vibrated blocks was 9 per cent. less than that of those made in the usual way without vibration. In the second set slightly more water was used in the mix, and the tests showed that the strength of the vibrated and unvibrated blocks was approximately the same ; as compared with the first set, however, the strength of the second set was considerably lower, although the results were more uniform.

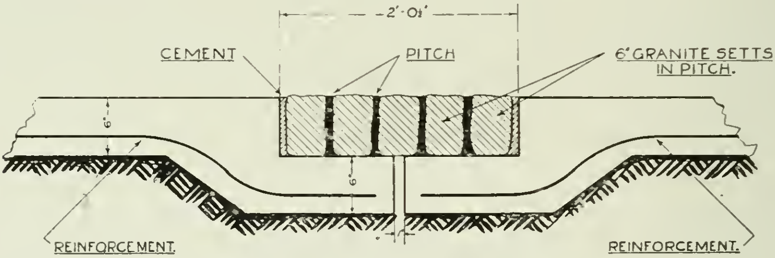
The new building being erected at Teddington for research work into concrete and cement is now rapidly nearing completion, and it is expected that a series of tests will soon be undertaken.

FRACTURE OF REINFORCED CONCRETE ROAD OWING TO EXPANSION.

By **T. CARMICHAEL,** Engineer Portsea Island Gas Company.

THE reinforced concrete roads laid down at the Hilsea Gas Works, Portsmouth, by the Portsea Island Gas Light Company, and described in our issue for June, 1920, have been in constant use since that date. They have been carrying heavy traffic, consisting of steam wagons, tractors, etc., and with one exception have been entirely successful.

Early in the summer of 1920 the trial length of 725 feet of road laid in Green Lanes fractured at about its centre, owing to expansion. The road was exposed to the full force of the sun, and in the middle of the afternoon, when the temperature in the sun was considerably above 100° F., it was found to have cracked at right angles to its length and for the whole width. The crack occurred at a " joint," or, in other words, at the end of a day's work, and the expansion of the road had apparently sheared off the edge on one side, exposing the 18-in. strip of reinforcing fabric which was introduced into these joints. The sheared portion was triangular in section, and apart from crumbling for about 1 ft. on each side of the fracture, no other damage appeared to have been done.



The damaged road was repaired in the usual way, by stripping off the concrete, re-bonding the reinforcing fabric, replacing the concrete and tarring. The repair was thoroughly satisfactory, giving no trouble since being completed.

In June of this year, however, a similar fracture suddenly occurred at a " joint " two days' work from the previous one. This second fracture was similar in every respect to that of last year, except that it appeared to have been more severe, and in fact the reinforcing fabric was considerably buckled.

When this road was repaired, and in order to obviate further damage from the same cause, an expansion joint was put into the centre of each of the roads. A sketch is given herewith of the section of expansion joint, which was devised by the writer. Although considerably hotter weather has been experienced since these joints were put in, no further cracks have appeared, and it is thought that this simple joint has obviated any further trouble.

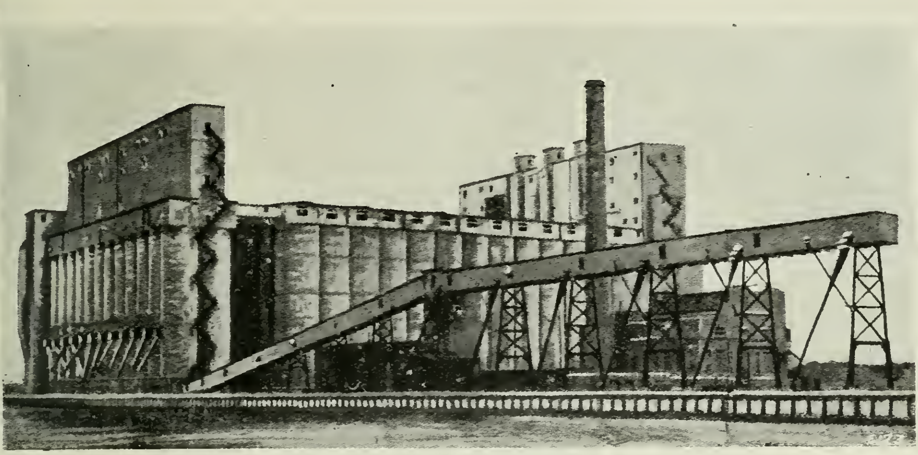


FIG. 1. GRAIN ELEVATOR AS IT APPEARED BEFORE THE EXPLOSION.

GRAIN DUST EXPLOSION.

THE accompanying illustrations and particulars of a grain dust explosion at Chicago are reproduced from our contemporary *Concrete*, U.S.A., and whilst the causes of this explosion are still under investigation, the information is interesting and presents a problem for the consideration of the engineer responsible for the design of structures liable to such explosions. We cannot do better than reproduce the particulars just as they are given. Following upon this, however, we continue to reproduce some extracts from an article in *Engineering News-Record* bearing upon the whole subject. The account of the explosion in *Concrete* reads as follows :—

GRAIN DUST EXPLOSION, CHICAGO.

The huge elevator of the Armour Grain Co., South Chicago, which was perhaps the largest concrete grain elevator in the world, was partially destroyed at 6.20 p.m., March 19, in the explosion of mill dust. Very fortunately, twenty minutes previously, the day force of 200 men quit work, and the minimum night force of twelve men went on duty. This prevented a greater human casualty and kept the list down to six killed and a dozen wounded. The explosion broke windows within a radius of five miles, and started a number of small fires, while the disturbance was heard across the lake, in Michigan.

The elevator was the property of the Chicago & North-western Railroad Co., and was leased to the Armour Company. The original cost was $3,000,000, while three years were consumed in building, the structure being only completed late last year.

The plant consisted of a nest of thirty-two elevators of steel and reinforced concrete, and comprised 240 separate concrete grain storage pits. The superstructure in which the loading and drying rooms were located, was of steel and frame construction, encased in gunite about 4½ in. to 5 in. thick, and reinforced with wire. Gunite was used on the elevators for just such explosions, because, it is claimed, it will give way, leaving the steel to stand up under the strain.

The explosion ripped away the light steel superstructure in the centre of the plant and blew off the gunite from both side sections, leaving the steel standing or else badly bent and twisted. Sections of gunite were blown for a radius of a city block or more, and covered the immediate vicinity of the elevators. The train shed, which was immediately to the west of the plant, was demolished, both by the blast and the weight of the masses of gunite and steel that fell from the superstructure. *Fig.* 3 shows a large steel framework that was ripped from the top of the plant and blown into the Calumet River.

The terrific force of grain dust explosions has long been known, and for several years the Government has been carrying on a campaign with the idea of preventing just such catastrophes in flour mills and grain elevators. That such an explosion should occur in what was the best equipped and most carefully guarded elevator in the country, is one of those mysteries yet to be explained.

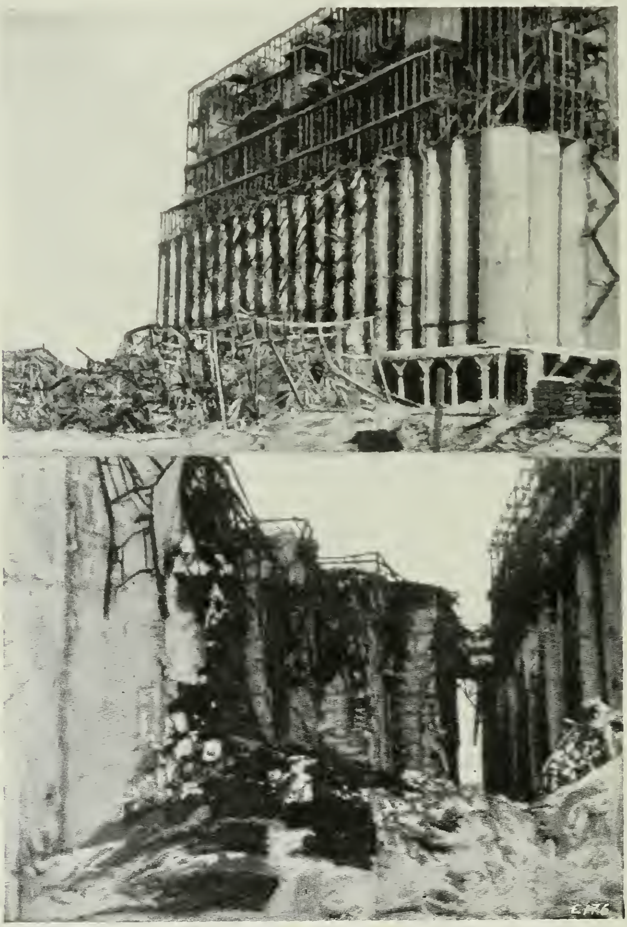


Fig. 2. (Upper) Main Structure after the Explosion. (Lower) Some of the Wrecked Grain Bins, with Contents scattered on the Ground.

The function of this mammoth plant was not only to provide storage for 10,000,000 bushels of grain, but also to handle large volumes of it in a rapid manner. Grain has been received from cars at the rate of thirty-six carloads per hour, and from boats at a maximum rate of 20,000 bushels per hour. The shipping capacity by rail was forty-eight carloads per hour, and the maximum loading capacity of the river house was 467,000 bushels.

Fifteen separate structures were included in the plant, five of which—the working house, storage house, river house, marine tower and track shed—were so closely connected as to practically be under one roof. Other portions of the plant which were housed in separate structures were the office building, dust house, power plant and several miscellaneous departments. In addition to these structures, there were 10½ miles of track, which provided storage for 1,450 cars. The large marine tower, which unloaded boats to the river house, was 28 ft. by 32 ft. and 145 ft. high, and was built of structural steel covered with cement plaster. All the machinery was operated by electricity.

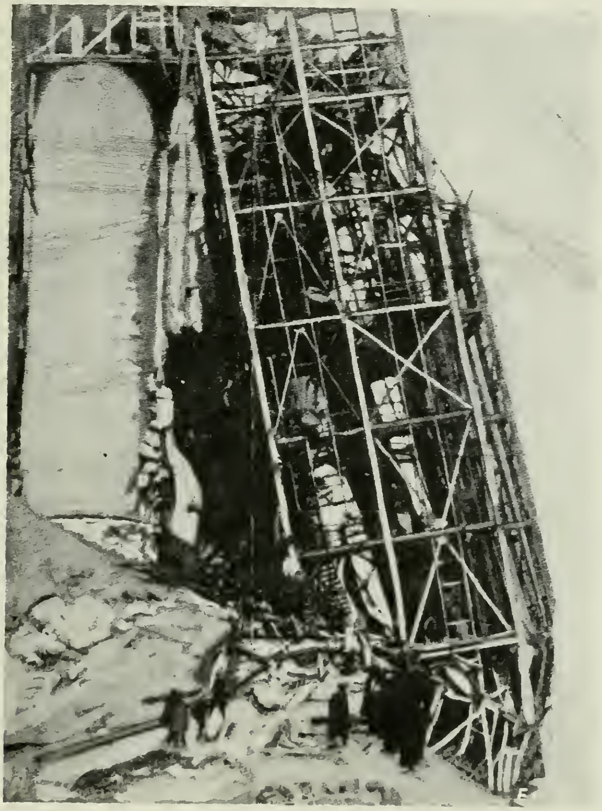


FIG. 3. THE WRECKED MARINE TOWER.

Not all of the plant, however, was destroyed by the blast. At the north-west corner, diagonally across from the section where the damage was heaviest, many bins are intact, and even at other points may be found bins that on the exterior show no signs of being damaged, or else show long diagonal cracks. The thirty-two bins were all built of reinforced concrete, and thus withstood the shocks well. Most of the grain in them will be saved.

The elevator contained 7,500,000 bushels of grain, while 100,000 bushels of corn and barley were in the drying rooms. Tons of the grain poured into the river, while "hills" of it were released and lay alongside the ruins, as shown in *Fig.* 2.

The fire, which caused the blast, it was claimed, started in the tunnel leading from the unloading platforms on the west side of the plant to the drying room. A few seconds later it had spread through the dust-laden air into the drying room, and then into eight bins on the east side of the plant.

In an article in *Engineering News-Record* Mr. David J. Price, Engineer-in-Charge, Development Work, Bureau of Chemistry, U.S. Department of Agriculture, says :—

Before these explosions can be prevented, it is necessary to determine the various causes and circumstances under which dusts can be ignited, the manner in which the explosion spreads or propagates, the ignition temperature of the various dusts, the pressures developed and also the effectiveness of any methods which may be designed for prevention. Dust explosions have occurred most frequently in plants where grain or grain products are milled or handled, such as grain elevators, flour mills, feed and cereal mills, and starch factories. They have occurred also in sugar refineries, cocoa and chocolate plants, candy factories, spice works, wood working establishments, paper mills and printing plants, shoe factories, fertiliser works, cork grinding plants, drug and herb works, and other industrial plants where dusts are created. Explosions of aluminium and magnesium dusts have also taken place. Many disastrous smut and grain dust explosions have occurred in threshing machines in the Pacific north-west, while a large number of fires have occurred in cotton gins during the ginning process.

A dust explosion appears to be very similar to a gas explosion, although particles in a dust cloud are larger than the minute molecules in a gas. Both require a proper mixture of air and ignition by some external source of heat or flame, it being impossible to produce " spontaneous " explosion. In the study of dust explosions by the U.S. Bureau of Chemistry ignition temperatures resulting in propagation were determined as follows : 2,363° F. for wheat elevator dust, 2,300° for flour, 1,821° for oat and corn elevator dust, 1,868° for oat hull dust and 1,877° for yellow corn dust.

Two theories are prominent in explanation of the action that takes place during the progress of dust explosions : (1) That a distillation of flammable gases occurs when the dust becomes heated ; (2) that the explosion is nothing more than a rapid communication of flame or fire from one particle to another, depending to a large degree on the fineness of the dust. That is, the finer the dust and the lower the moisture content the more rapid the propagation and the greater the violence of explosion. This seems to establish very definitely a relation between fire and explosion.

In many cases a primary explosion, which is nothing more than a small puff, is followed by fire in which the property is extensively damaged or destroyed. In other cases a series of increasingly violent explosions follows, indicating that if dust is present to feed the original flame an explosion will follow. In plants where little dust is in suspension and where " good housekeeping " is practised, the occurrence merely assumes the proportions of a fire and no violent explosion results. Reference is made to this phenomenon to emphasise the fact that a disastrous dust explosion may occur during the course of any fire if sufficient combustible dust is present to feed the flame and allow it to propagate. The dust that accumulates throughout the plant is thrown into suspension by slight concussion, with the result that a primary " ignition " or explosion develops into a secondary explosion of large proportions.

The rate of propagation or flame travel in a dust explosion depends upon the flammability of the dust and the amount of it in suspension. Reports of the U.S. Bureau of Mines give the average velocity of flame in coal dust explosions as 2,270 ft. per second ; British and French investigators report 2,114 and 3,300 ft. per second respectively. The velocity is usually more rapid in gas mixtures than through dust clouds. Limited tests indicate that the velocity through a cloud of wheat-flour dust is practically the same as through coal dust, and that through a cloud of powdered starch it is several times as rapid as through coal dust.

Tests conducted on a large scale by the Bureau of Mines show a pressure of 103 lb. per square inch with coal dust. From extensive laboratory tests by the Bureau of Mines and the Bureau of Chemistry, based on only 75 mg. of dust in standard laboratory apparatus, the results shown in the accompanying table have been obtained.

The values shown there are much smaller than those obtained in full-sized tests, but interesting as a comparison of the behaviour of different materials. That grain dusts are more flammable than coal dust is confirmed by tests on a large scale. In recent tests conducted in co-operation with the Bureau of Mines in its testing galleries it was found that flour and coal dusts acted similarly. Starch dust propagated more rapidly, produced higher pressures.

Dust.	Lb. per sq. in.	Dust.	Lb. per sq. in.
Lycopodium	17·5	Sugar	12·2
Wheat smut dust	15·9	Potato flour	11·7
Yellow corn	15·2	Fertiliser	10·5
Dextrine	14·6	Coal (Pittsburgh)	10·1
Tan bark	13·3	Cocoa	9·1
Wheat elevator dust	13·0	Sulphur	8·8
Wood dust	12·8	Cork	7·4
Corn starch	12·7		

Efforts are being made to establish proportions of dust in suspension necessary for an explosion. Laboratory tests indicate that only 10 lb. of dust in suspension would be needed in a closed room containing 4,466 cu. ft., or a room 10 by 30 by 15 ft.

The relation of humidity to the frequency of dust explosions has been markedly noticeable in the investigational work. This is especially true of explosions where static electricity has appeared as a probable cause. Although this relation has not been definitely determined in industrial plants, it is reasonable to conclude that the dust explosion hazard is greater during periods of continued low humidity.

A close relation between the construction of a plant and the extent of an explosion within it has been developed by the investigation of a number of disastrous dust explosions in grain handling plants, especially in the large terminal grain elevators.

The writer concludes by giving some suggestions with regard to the construction and the installation of mechanical equipment with a view to preventing such explosion. Dealing with the construction of walls, windows and doors, he says :—

Walls, Windows and Doors.—To prevent high pressures from being built up within heavy concrete wall construction, consideration might be given to the use of a thin wall offering little resistance to the great volume of gases produced by the ignition of the dust. In such a building all the working stresses would be placed upon the concrete columns and beams, the walls serving only as a filler or curtain. Large window area, or the daylight type of building construction, affords another means of preventing high interior pressures. Windows of the steel sash type, self supporting and extending from the ceiling to the floor, would be preferable. Steel curtain doors have been used on the working floors of grain elevators. They can be opened during the day, providing good ventilation to the working floor and a vent for any explosion on this floor.

MEMORANDUM.

Concrete in Hospital Construction.—Mr. Edwin T. Hull, F.R.I.B.A., the well known hospital architect, in the course of a paper read at the annual congress of the Royal Sanitary Institute, mentioned that the cheapest hospital he had designed, namely, the hospital built under the National Insurance Act for the King Edward Memorial Association at Pontywal, Breconshire, containing over 300 beds, was of concrete construction, the total cost of the buildings, fittings, plant, furniture, etc., working out at a pre-war cost of £175 per bed. The walls were of concrete 3 in. thick on a wire mesh reinforcement, the whole building being in the form of a monolith on a 6 in. concrete raft. In his opinion, with this type of construction one-storey wards, which were preferable to high buildings, could be built more cheaply than the latter.

QUESTIONS AND ANSWERS RELATING TO CONCRETE.

In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—Ed.

Question.—F. C. writes :—Will you kindly in the correspondence columns explain if I can check the following example given on page 82 of Mr. Andrews' "Elementary Reinforced Concrete Construction" as follows :—

A rectangular slab 18 ft. long and 12 ft. wide is to carry a uniformly distributed load of 200 lb. per sq. ft. ; ends simply supported ; slab 6 in. to c of reinforcement, find a suitable reinforcement.

Short span B.M. = 648,000 in.-lb., t 16,000 by diagram page 25, B 58 reinforcement = ·418 sq. in.

Should I be able to check this by the L.C.C. formula for slabs as follows :—

$$\frac{wl}{8} \times \frac{1}{1 + (b/l)^4} = B.M.$$

$$= \frac{220 \times 12}{8} \times \frac{1}{1 + \left(\frac{12}{18}\right)^4}$$

given on page 186.

Answer.—The L.C.C. formula referred to is used to ascertain the proportion of the bending moment carried by the length or breadth of slab.

In the given problem the proportion = ·83 was obtained from the curve (*Fig.* 14) based on the Grashof and Rankine Theory.

The coefficients in this theory are :—

$$\frac{a^4}{a^4 + b^4} = \frac{1}{1 + \left(\frac{b}{a}\right)^4} \text{ and}$$

$$\frac{b^4}{a^4 + b^4} = \frac{1}{1 + \left(\frac{a}{b}\right)^4}$$

This theory is the one employed in the L.C.C. regulations. In the case referred to :—

$$\frac{1}{1 + \left(\frac{12}{18}\right)^4} = \frac{1}{1·1975} = ·83 \text{ approx. as}$$

given by the diagram.

Full B.M. on short span =

$$\frac{Wb}{8} = \frac{200 \times 18 \times 12 \times 12 \times 12}{8}$$

$$= 780,000 \text{ in.-lb. approx.}$$

Multiplying by ·83 we get the B.M. to be designed for = 780,000 × ·83 = 648,000 in.-lb. approx. (slide rule). The remaining calculation should be found to check with the L.C.C. regulations ; if the enquirer has had any difficulty in this respect it is probably due to the common error of taking *w* the load per square foot, in place of *W* the total load in the calculation for the bending moment.

Question.—Messrs. B. & Co. write :—We put up a building for Lager brewing "Bottom Fermentation," and we have found great difficulty in getting a suitable mixture for water-proofing tanks, so that we could put an outside dressing of shellac, so as to preserve the beer from coming in contact with the cement. Shellac, without some other water-proofing coating is of no use.

In the book reviewed in your journal entitled "Popular Handbook for Cement and Concrete Users," the author suggests the paraffin hot and cold process, which would suit us, as paraffin has no deleterious effect on beer. Although we have made several attempts, we have not been successful in obtaining a mixture that would hold on to the cement and form an impervious coating. We would be extremely obliged if you could by any means direct us where to get the desired information.

The tanks mentioned would contain Lager at a temperature of 32° Fah. for a period of from twelve to sixteen weeks.

Answer.—The general question of water-proofing concrete tanks is much too large to be discussed here, but the question of the use of paraffin wax for this purpose is far less complex. Before considering the two usual methods of application and their limitations, it will be as well to note the chief properties of the wax for this purpose. These are as follows :—

(1) The wax is brittle, even just below its softening point, and therefore is not effective on a flexible base, in its pure state.

(2) It softens and melts at a comparatively low temperature, which limits its application.

(3) It shrinks considerably on solidifying.

(4) Its adhesive power is slight, and in order to make a good bond it must penetrate the surface of the material.

With these properties in mind, we can consider the two methods of applying the wax. The cold process consists in dissolving the wax in a suitable volatile solvent, and applying the solution to the surface to be proofed, which, of course, must be dry. If the surface is sufficiently porous, the solution is absorbed, and as the solvent evaporates it leaves a film of paraffin wax on, and in the pores of, the surface. The wax, however, is not tough and flexible like a film of dried linseed oil or varnish, and consequently may contain cracks and holes. For this reason the surface will not be water-proof in the strict sense, but the water-repellent action of the wax is so great, that the surface becomes "water-proof" in the sense of enabling vertical walls, etc., to resist the action of rain. Repeated application of the solution will in time fill up these interstices.

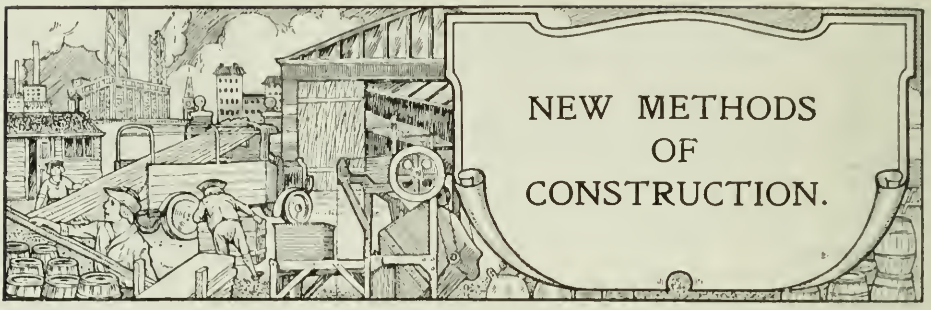
The hot process consists in heating the surface to be coated, and then applying the melted wax, which penetrates into some of the pores in the surface. Provided the conditions are right, the water-proofing effect is very good, but if the surface is not sufficiently porous, or is not hot enough, so that the wax is chilled, the bond is very feeble and the wax readily peels off. Also the shrinkage of the wax is so great that occasionally the wax cracks, and is no longer water-proof. These defects may sometimes be overcome by hot "ironing."

Where the surface is not sufficiently porous for the hot process, but will allow the cold solution to penetrate, a combination of the two methods may prove very successful. The cold process enables the wax to get a thorough bond, and the hot process completes the water-proofing effect.

If the surface of the tank has been worked so that practically neat cement has been floated up, the surface may be so dense and glasslike that the wax cannot make any bond. In such a case it will be better to drop the idea of using paraffin wax for the purpose.

MEMORANDUM.

Some Things to Be Learned About Concrete.—The Committee on Research of the American Concrete Institute in its report to the recent convention gives the following subjects that need study in the field of concrete : 1. Proper methods of measuring quantities going into a batch of concrete. 2. Collection and correlation of data to show quantity of set concrete which can be made from given amounts of different aggregates. 3. Establishment of a standard screen scale for concrete aggregates and limits of variation in sizes of different classes of aggregates. 4. A standard field method for determining consistency of concrete. 5. A standard field test for strength of concrete. 6. Tests to ascertain the efficiency of various types of mixers in making concrete. 7. The allowable variations in sizings of aggregates. 8. An index of quality of aggregates as determining their value in concrete. 9. An abrasion test for gravel. 10. The production of plant-mixed aggregate. 11. A method of evaluating various forms of mechanical anchorage of reinforcing bars in reinforced-concrete beams and slabs. 12. The value of clay tile built in with concrete beams in adding to the shearing resistance of the beam. 13. Relative values of rectangular and T-shaped or I-shaped reinforced-concrete beams in resistance to shear. 14. A method of evaluating bent-up bars as shear reinforcement for concrete beams. 15. A study of corrosion in reinforcement in contact with salt water or salt air. 16. Bond stresses in two-way reinforcing, as in footings. 17. Adjustment of steel stresses due to plasticity of concrete. 18. Test of chuted concrete. 19. Central mixing plants.



NEW METHODS OF CONSTRUCTION.

"THE ELZED SYSTEM."

This system is primarily one of pre-cast units. It has been designed to make even the setting out of a building a comparatively simple operation and to utilize unskilled labour, both in the manufacture of the units and in the construction of the building, as no special care is needed to ensure the walls being perfectly plumb and horizontal, whilst the bonding is perfect.

The main unit of the system is a Z-shaped block forming both front and back faces of walls of any thickness. To complete a building there are also needed corner blocks, L-shaped blocks, and sill plates (and for two-storey buildings a corbel course to carry first floor joists), and the usual heads to cover door and window openings.

The main external walls of a building, say, 30 ft. by 20 ft. 3 in. by 16 ft. 6 in. high with, say, 4 window openings 4 ft. 6 in. by 3 ft. and 2 door openings 6 ft. 9 in. by 3 ft. require approximately 18,000 bricks for 9 in. walls. A similar building on the "Elzed" System will require approximately :—

276 base plates to be used at bottom and top of walls and for window and door sills ; 8 base plates to be used at corners both top and bottom of walls ; 2,605 Z blocks ; 88 corner blocks ; and 84 L blocks.

i.e., the total number of blocks is about one-sixth that of the number of bricks required for a similar building, hence one block is equivalent to six bricks ; in addition six bricks require 243 square inches of mortar joint, but one "Elzed" block requires only 46 square inches, i.e., about one-fifth, in fact the blocks could be laid dry under certain circumstances.

The most important unit is the Z block, and this should of course be made by machinery for maximum of output. The L and corner blocks can be made with the same machine as the Z block, whilst the base plates and other fittings can be made in hand moulds, unless a large quantity is required, when it would pay to utilize machinery in the majority of cases.

For hollow concrete construction the walls of blocks are to be 2 in. thick for one or two storeys, but for poured concrete work the walls need only be 1 in. thick, thus forming a permanent shuttering and part of the wall itself and so save the use and waste of timber shuttering.

The blocks are to be made of material according to the purpose for which the block is to be used—thus, if they are used for finished face, one wall would be of granite chippings or shingle concrete and the other of breeze concrete ; if both sides are to be covered (roughcast and plaster), then both walls can be made of breeze concrete.

Description of Units.

Base Plates. These consist of plates for corners and main walling and are also used (inverted) for eaves course and sills. The wall base plates are to be, say, 9 in. long by 3 in. thick with 3 in. sunk margins ($1\frac{1}{2}$ in. deep) on three sides.

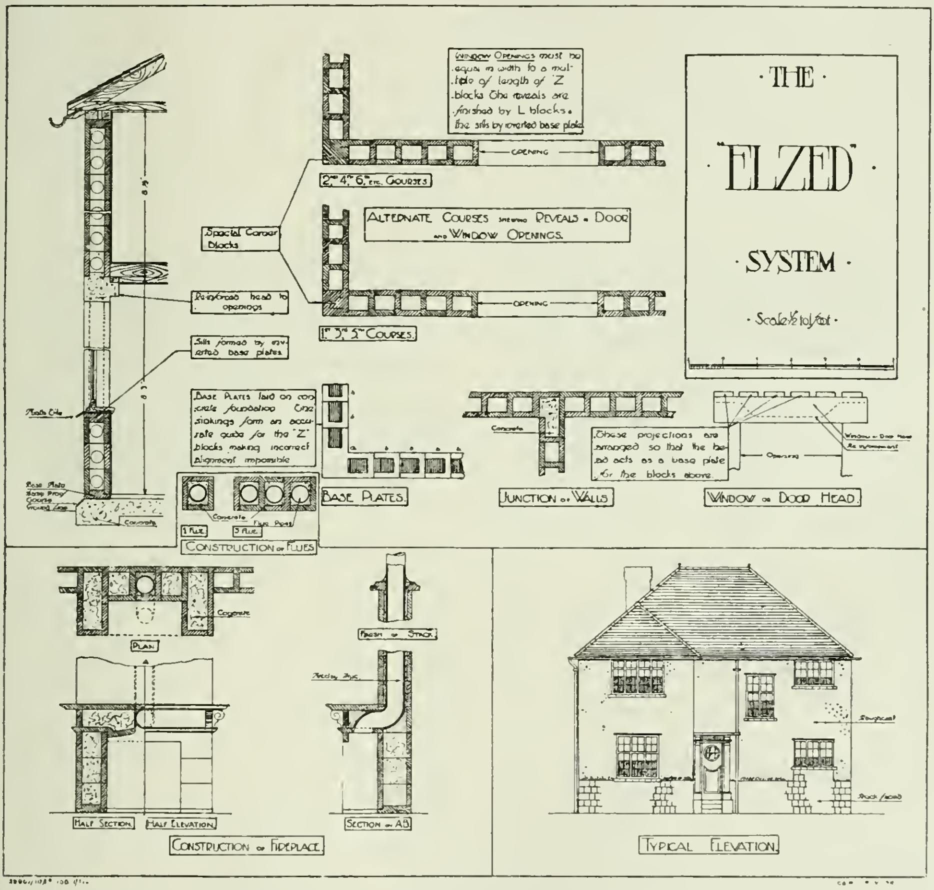
Wall Blocks. The wall blocks are of Z shape 9 in. long on each face by, say, 9 in. high, but any dimension can be adopted. A building must in length and height be multiples of the length and height of blocks. The L blocks for reveals to be of similar dimensions to the Z blocks.

The Web of the Z block is perforated for easier handling and to allow a current of air to pass through the whole length and breadth of wall.

Door and Window Heads. To be of same height as blocks and reinforced where necessary and to be solid.

Support for First Floor Joists. The ordinary Z block with nib cast on back or a special block can be used, the wall plate being laid on this nib to take the joists.

Similar shapes can be used for construction of rectangular and angular fireplaces and flues. The jambs need only be carried to mantel level and then covered with a hood and mantel within which is a smoke flue connected to the flue within one of the rectangles formed by the Z blocks in the wall at the back of the fireplace.


· THE ·
· "ELZED" ·
· SYSTEM ·
· Scale ½ to 1 foot ·
Window Openings must be equal in width to a multiple of length of "Z" blocks The reveals are finished by L blocks. The sills by inverted base plates
OPENING
2nd 4th 6th etc. Courses
Alternate Courses shewing Reveals of Door and Window Openings.
Special Corner Blocks
OPENING
1st 3rd 5th Courses.
Reinforced head to openings
Sills formed by inverted base plates
Base Plates laid on concrete foundation The sinkings form an accurate guide for the "Z" blocks making incorrect alignment impossible
Base Plate
Damp Proof Course
Ground Line
Concrete
Concrete
Flue Pipes
1 Flue.
3 Flue.
Construction of Flues
Base Plates.
Concrete
Junction of Walls
These projections are arranged so that the head acts as a base plate for the blocks above.
Window or Door Head
Reinforcement
Opening
Window or Door Head.
Concrete
Plan
Finish of Stack
Half Section
Half Elevation
Section on AB
Construction of Fireplace
Typical Elevation.

Party walls, square and cant projections can also be constructed by the system.

Building Operations. The site to be covered with a concrete raft in the usual manner, care being taken that the upper surface of same is quite level for a distance of 12 in. round outer edge. If this is not done then the base plates, mentioned next, must be bedded level.

After the concrete raft is laid, corner base plates (as "a" on plan) are to be laid and the intervening spaces filled in with base plates ("b" on plan). This ensures a perfectly rectangular building, the sinkings in the base plates forming an accurate guide for the reception of the members of the Z blocks and thus making it impossible for an unskilled man to get out of line.

After base plates are laid the first wall course is laid. In the first place a corner

(*Continued on page* 551.)

CEMENT NOTES.

The following Notes regarding Cement have been abstracted from our Foreign contemporaries.—Ed.

Substitutes for Cement.

The high cost of Portland cement on the Continent has led to innumerable substitutes, none of which have proved to be really satisfactory. It is true that some samples of hydraulic lime resemble Portland cement so closely, that they might form an efficient substitute, but unfortunately no reliance can be placed on successive deliveries of hydraulic lime, so that material cannot really be compared with Portland cement.

Even more risky are the numerous substances which have been dignified with a name, such as Cementin, Silikalite, etc., because the name may convey the idea that the material has a special value when, in reality, it may be hydraulic lime, possibly with some slight additions of small technical value.

The essential feature about Portland cement is that its manufacture is controlled throughout by scientific tests, which if acted upon, ensure its constant composition and properties, whilst substitutes—no matter how pompous their names—are not made under such careful control, and their behaviour when in use is therefore more uncertain. In some cases the differences are so large as to make their employment risky or even dangerous.—*Tonind. Ztg.*

The Thermal Effects on Heating Cement Meal.

A well-known method of ascertaining whether any decomposition or other change occurs in a substance when it is heated, consists in heating a little of the substance in a crucible in an electric furnace in such a manner that the temperature of the crucible rises at a perfectly uniform rate. A pyrometer is then placed in the contents of the crucible and it is found that, with many minerals, the temperature recorded by the pyrometer does not rise regularly but shows a "lag" or "rest" at some points and a sudden rise of temperature (during which the substance becomes hotter than the furnace) at other points. The lag is caused by the heat absorbed by the substance being so great that the temperature cannot rise ; this is an indication of an endo-thermal or heat-absorbing reaction which occurs at the given temperature. A "hump" in the time-temperature curve of the experiment indicates that the substance is giving out heat and that an exothermal reaction is taking place.

These reactions in the case of silica, alumina and clay are well known, but it is only quite recently that they have been examined in the case of Portland cement. Dr. K. Endell, of Berlin, has found that the mixture of limestone and clay used in the manufacture of Portland cement at Rüdersdorf gave a steady curve until the temperature of 930° C. was reached, when a short "rest" indicating an endothermal reaction occurs. The temperature then rose steadily until a temperature of 1200° C. was reached when an exothermal reaction occurs. A mixture of blast furnace slag and limestone and various natural cement meals (i.e. marls containing clay and chalk in just the proportion required for Portland cement) gave the same effect.

Dr. Endell attributes the absorption of heat at 930° C. to the evolution of carbon dioxide from the limestone or chalk present, and the exothermal reaction at 1200–1300° C. to the fusion of the clinker. This exothermal "hump" is much clearer if the limestone or chalk has previously been heated so as to remove all carbon dioxide.

The remarkable feature of these curves is the absence of the two points which are so strongly marked when clays are heated in a similar manner. With clay there is a marked endothermal reaction at about 600° C.—due to the decomposition of the clay—and an exothermal reaction at about 1000° C., the precise nature of which has never been fully ascertained ; it has been attributed to the polymerisation of alumina. In the case of Portland cement meal, the exothermal reaction of the clay at 1000° C. may be obscured by the heat absorbed by the evolution of carbon dioxide.

There is also a slight "notch" at 1200–1300° C. in the curve of some clays, owing to the formation of sillimanite. This may or may not account for the "notch" at 1300° C. in Dr. Endell's curves.—*Zement,* 1921, pp. 201–203.

SOME EXTRACTS FROM THE FOREIGN PRESS.

CONCRETE RAILWAY TRUCKS.

ATTENTION has previously been called in these pages to the use of concrete for railway trucks, and in an earlier number we gave particulars of such trucks as they had been evolved in the United States. A considerable amount of study appears to have been devoted to the subject on the Continent, and in our April number we illustrated and briefly described some wagons which had been built in Hungary. We are now able to give further particulars of continental developments in this direction as gleaned from recent issues of *Béton u. Eisen.*

The railway truck shown in *Fig.* 1, constructed of concrete, represents an early example of the utilisation of this material in wagon-building. It cracked at each end in several places yet was in continuous use from the 6th February to the 6th September, 1920—a period of seven months—in which it made journeys amounting to 1,500 miles. On investigation it was found that the cracks were due to a very large lump of ironstone being thrown forcibly and intentionally into the half-empty wagon. Such an occurrence is rare, but wagons ought to be able to resist such treatment.

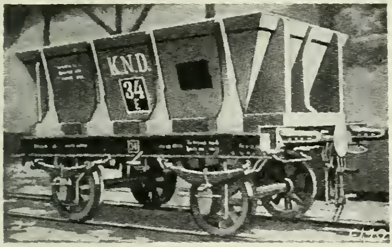


FIG. 1.

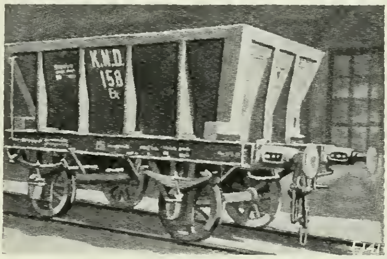


FIG. 2.

Truck 158 (*Fig.* 2) was in regular use for five months in 1920, during which time it travelled 2,700 miles without needing any repairs. At the end of this period it showed several small cracks, but these did not appear to affect its strength, as it was undamaged after collision with several other trucks. This truck weighed $2\frac{1}{2}$ tons. When building it, the concrete remained 18 days in the forms and was used after a further period of 42 days.

Truck 156 of the same type was in use for $2\frac{1}{2}$ months prior to this report without any sign of cracking; it was only 14 days in the forms and was used after a further period of 30 days.

Truck 145—also of the same type—received a heavy blow shortly after being used and numerous fine cracks were found at the corners. The truck was used continuously up to the time of the report, without any change occurring in the cracks. It was only 12 days in the forms and was used after a further period of 24 days.

Other trucks proved equally satisfactory, and the time of remaining in the forms and also of hardening before use was reduced to 7 days each respectively.

The actual time spent in erecting the forms and placing the concrete was only 178 hours per truck, divided as follows:

2 carpenters on forms	$2\frac{1}{2}$–3 days
2 men placing reinforcement	$\frac{1}{2}$ day
7 men placing the concrete	$\frac{1}{2}$ day

The remainder of the time was occupied in bending the reinforcement, removing the forms, etc. Later, iron forms and mechanical mixers were used and the cost considerably reduced.

The weight of the concrete body averaged $1\frac{3}{4}$ tons as compared with 9–13 cwt. for wooden bodies and 18 cwt. for iron. If light concrete were to be used the weight of the body would be reduced to 1¼ tons, and by designing special trucks for the various industries the actual power required for haulage need not be appreciably increased.

Even with the greatest difference in weight between concrete and other trucks, viz. 16 cwt., the actual increase in coal required for drawing it is under 3 tons per annum, and as there is no necessity to use such heavy trucks, an allowance of 1 ton of coal per truck per annum will more than account for hauling the extra weight.

Against this must be set the marked increase in the cost of iron and general cost of construction and repairs.

CONCRETE SAFES.

The use of reinforced concrete in the construction of strong rooms is by no means new, but the use of this material for safes is more novel. By means of this material safes can be constructed in places where their cost would be almost prohibitive, as the cost of transport of such exceptionally heavy and cumbersome articles as steel safes is naturally excessive.

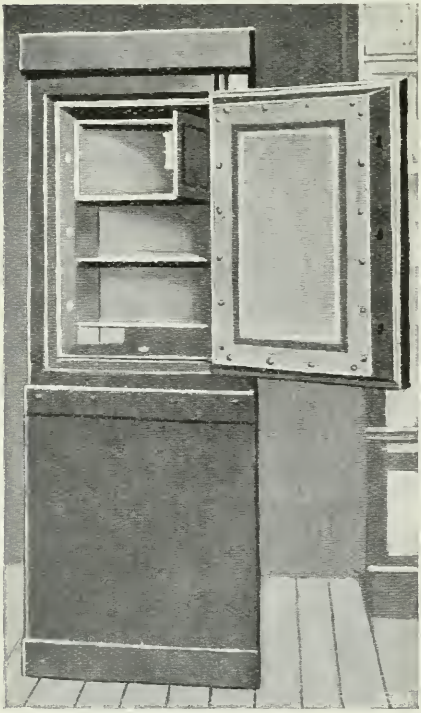
If properly constructed of suitably reinforced concrete and using a hard aggregate, a safe is quite as resistant to a blowpipe or to the ordinary methods of burglary.

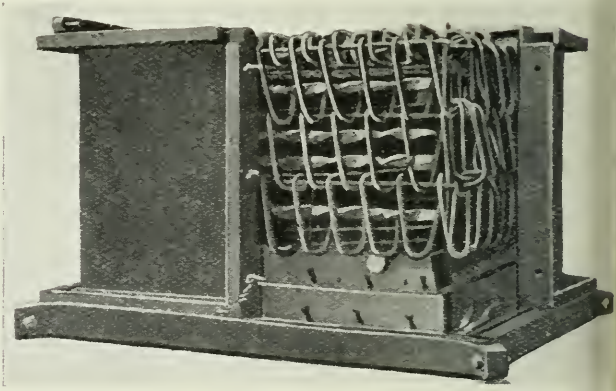
In a new method, patented by C.M.B. Soc. anon de Coffres forts et Meubles en Béton Armé the body and door of the safe are cast separately in metal moulds, a trellis work reinforcement being employed.

The security of a light metal safe may be greatly increased by surrounding it with a casing of reinforced concrete.

As the fitting of the door must be very exact special care is needed with this part of the construction.

Safes of reinforced concrete may be painted and varnished in such a manner as to be indistinguishable from those made of steel, and they may be fitted with shelves of steel or concrete, as desired.—*Revue du Béton Armé.*

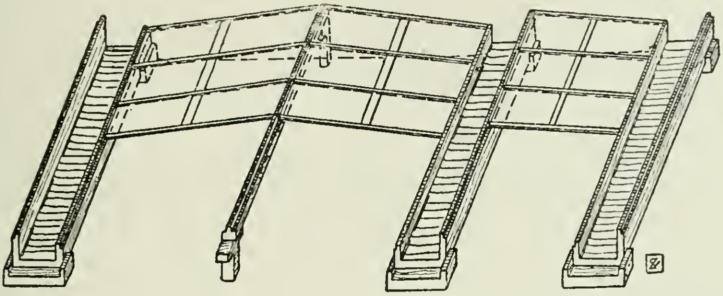




Figs. 1 and 2.
Showing Finished Safe and Method of Reinforcement.

CONCRETE GARDEN FRAMES.

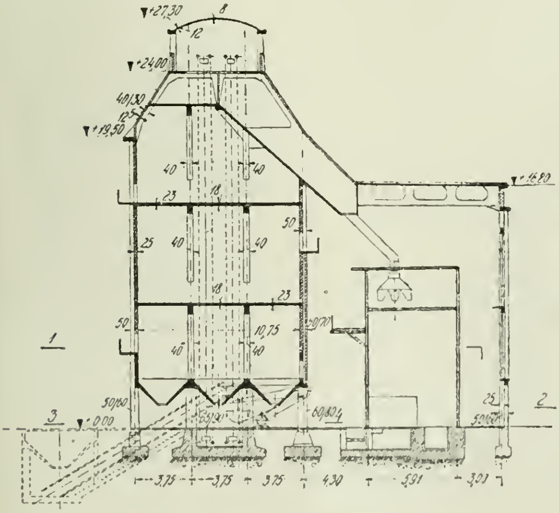
As a substitute for wood in garden frames, the use of concrete channel blocks of the shape shown in the accompanying illustration appears worth consideration. The channel block is made separately from the two supporting blocks, the latter regulating the height and slope of the frames. An intermediate support—also of concrete—and plain concrete blocks or slabs to enclose the space below the channel blocks are easily provided. The arrangement has been patented in Germany but not in the British Isles.



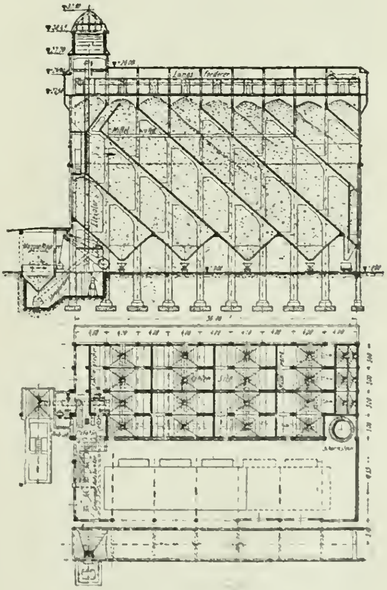
A COAL STORE OF REINFORCED CONCRETE.

The Heidelberg Gas Works have recently had built a large coal store of reinforced concrete. This bin holds 5,000 tons of coal and is capable of delivering coal to any of the five coke ovens which may require it. In its construction special efforts were made to save labour, and cranes were used extensively for this purpose. Apart from this there is nothing very novel in the construction.

A still larger concrete coal store at Esslingen has a capacity of 6,000 tons, but is otherwise of the same design. The novel feature of this store is the ventilation, which is effected by means of an inclined slot running the whole length of the store.—*Beten u Eisen.*



Silo, Heidelberg.



Coal Store, Esslingen.

ENQUIRY.

We should be glad if any of our readers who can furnish information on the point raised in the following enquiry would send us particulars for publication.—Ed.

To the Editor, Concrete and Constructional Engineering.

Dear Sir,—It would be interesting to know if any of your readers could recommend some suitable plastic material to fill up cracks in concrete. I am particularly referring to expansion or contraction cracks which cannot be suitably repaired by means of cement mortar or grout.

The material which I would like to find for this purpose, although plastic, would require to have a certain amount of hardness and it would be a great advantage that this material should be of the same colour as concrete.

Yours faithfully, G. C. Workman.

CORRESPONDENCE.

Under this heading we invite correspondence.

To the Editor, Concrete and Constructional Engineering.

Re Maintenance of Steel Construction as compared to Reinforced Concrete.

Dear Sir,—When setting out the advantages of reinforced concrete as against steelwork there is one great advantage in the former method of construction which, in the writer's opinion, is not sufficiently taken into account.

I am referring to the cost of re-painting which is required periodically in the case of steel constructions. In this respect it is interesting to notice the particulars which have recently been published in the *Contract Journal* of July 6th, concerning the tenders received by the City Corporation for the repainting of Tower Bridge and Blackfriars Bridge. It is stated that the accepted tender for the former amounts to no less than £19,889 17*s.* 7*d.*, and in the case of the latter, £10,124.

It is well-known, of course, that certain new bridges will be required over the Thames at some future date, and when the time comes to consider the merits of a steel bridge as against a reinforced concrete structure, it will be well to remember that in the case of reinforced concrete no painting whatever would be required; whereas in the case of a steel bridge this appears to be a very necessary and expensive item which is probably required and, in fact, absolutely necessary for the safety of such a bridge every ten years.

It is difficult to make any assumption concerning the life of a steel bridge of the size of Blackfriars Bridge, but if we assume this to be, say, seventy years, and that on an average it has to be re-painted every ten years, the total cost of re-painting alone would amount to no less than £70,000, a very considerable sum indeed. In the case of a reinforced concrete bridge of a similar nature this cost would be nil and the work would actually be much stronger at the end of seventy years, on account of the well-known hardening properties of concrete.

Yours faithfully, G. C. Workman.

A Letter from Engineer G. G., Bulgaria.

A correspondent asks us to publish the following letter, which may be of interest to reinforced concrete designing firms in this country:—

The attention of English Reinforced Concrete Engineering firms and Concrete Building Corporations in England is called to the big opening that exists in Bulgaria for extensive engineering works.

A lot of building will take place in the near future in Bulgaria. The Government has decided to build large elevators and silos, dams, canals, reinforced concrete bridges, etc. Industry in general—the flour industry in particular—is also improving. The building of large mills, store-houses, etc., is in progress, and others are projected for the near future. Shortly private buildings will assume large dimensions: according to the new Regulations all empty sites have to be built up by the year 1923, and those that are partly built upon—by the year 1925, otherwise such empty sites will be confiscated by the State. Apart from this, all banks, companies and private persons who have enriched themselves during the war are obliged, by the same law, to construct a large building in the shortest space of time. All this ensures a period of strenuous construction work in Bulgaria, where concrete as a building material will play an important part.

A financially well established, and technically sound English concrete corporation should have much success.

The following procedure is suggested :—

The installation in one of the Bulgarian ports of a large plant for manufacturing concrete blocks, bricks, ornaments, pipes, etc., a considerable part of which goods would find a ready market in Constantinople, which is poor in building-stone. Besides this installation there would also be a technical (engineering) bureau which would draw plans for houses, manufacturing plants, and all kinds of other buildings.

I am ready to furnish fuller particulars for the realisation of this idea, and also to undertake the carrying out of all preliminaries in connection with the organising of this enterprise.

Those interested may address all enquiries to the Editor of "CONCRETE AND CONSTRUCTIONAL ENGINEERING," for Engineer G. G., Bulgaria.

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

Par River Bridge.

SIR,—On page 449 of your July issue, it is stated that the above recently completed bridge "is believed to be the first underbridge on the Great Western Railway to be constructed of reinforced concrete."

You will probably be interested to learn that the structure in question is by no means the first reinforced concrete underbridge built on the Great Western Railway system, for in the year 1907 one of several reinforced concrete bridges and culverts constructed on the Avonmouth and Filton line of the same Company was a railway underbridge for mainline traffic, while in the succeeding year three reinforced concrete underbridges for mainline traffic were built in Bristol. All these structures were executed on the Hennebique system under the direction of Mr. W. Y. Armstrong, M.Inst.C.E., then engineer for New Works to the Great Western Railway Company.

I am, Sir,
Your obedient servant,
W. NOBLE TWELVETREES.

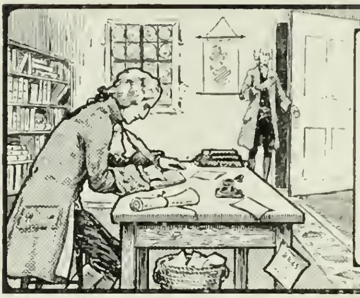
(*Continued from p.* 545.)

block is bedded on base plate and the Z blocks follow. The second course is carried out in an exactly similar manner except that the direction of each block is reversed. All that the "layer" has to do is to see that the crosspiece of a block is directly above that of the block below which ensures both front and back faces being upright and a perfect bond.

On reaching sill level the opening is set out equal in width to a multiple of the length of the Z block and the reveals finished by L blocks, the sills being formed of inverted base plates. No other sill is required except that a plinth tile may be used if desired.

The heads of the window and door openings are covered with solid heads as in ordinary construction, and, to retain the principle of facility in building, the upper face is made with projections similar to the base plates. When the top of a window is to be kept as near to the ceiling as possible, a nib is cast on the back side to carry wall plate. Inverted base plates are used at eaves level to receive wall plate to carry roof.

It is easier to construct roofs with hips on the "Elzed" system, although if gables are required they can either be carried up as a parapet and stepped, or the blocks made with bevels to rake of roof.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—Ed.

Effect of Colourings on Concrete Strength Determined by Test.—Discussing the paper on "Colouring Concrete," by John W. Lowell, before the recent annual meeting of the American Concrete Institute, Prof. Duff A. Abrams, of Lewis Institute, Chicago, gave the following report of some tests on the effect of these colouring agents on the strength of concrete.

The accompanying table gives the averages of the compressive strengths of 3 × 6 in. cylinders, made of 1 : 2 mortar and tested at ages of 7 and 28 days. Portland cement was used ; the aggregate was a coarse sand from Elgin, Ill. The percentages of colouring materials are in terms of the weight of the cement. Each value is the average of three tests made from a single batch of concrete. The tests on each colour were made at different times ; this accounts for the three values given in the third column for the mortars without colouring.

Colouring Material	Age at Test Days	Compressive Strength of Mortar Mixed with Different Percentages of Colour. Lb. per Sq. In.					
		None	0.5	2	5	10	15
French's C.U. Blue	7	2,100	..	2,500	2,960	3,210	3,720
French's C.U. Blue	28	3,390	..	3,990	3.990	4,630	4,900
J. M. Wells Co. No. 2 Red	7	2,790	..	2,750	2,590	2,450	2,270
J. M. Wells Co. No. 2 Red	28	4,900	..	4,780	4,390	4,410	4,090
Cabot's Carbon Black	7	2,840	1,820	1,610	870	690	..
Cabot's Carbon Black	28	5,080	4,240	3,070	2,000	940	..

It will be seen that three different effects were produced : The blue appears to possess some hydraulic properties which caused it to show a steady increase in strength up to the highest percentage used (15 per cent. of the weight of cement) at both 7 and 28 days. The red colour caused a slight reduction in strength which is practically the same as the effect produced by other inert powdered materials in concrete. The carbon black produced a very great reduction in strength ; 2 per cent. of carbon black reduced the concrete strength about 40 per cent. Bancroft in *Applied Colloidal Chemistry*, 1921, states that "with a substance like carbon black, which absorbs gas very markedly, as little as 5 per cent. of the apparent volume may be due to the carbon black, and a litre of carbon black may contain 2·5 litres of air." This peculiar property, no doubt, accounts for the effect on concrete shown by the tests.

A Large Grain Elevator.—Included in the comprehensive programme of grain elevator construction being carried out by the New South Wales Government is what is stated to be the largest structure of that kind in the world, now being erected at Sydney. The whole of the construction is of reinforced concrete, the main storage consisting of seventy-two large circular bins and seventy-one smaller bins, with a total capacity of 5¾ million bushels. A working house attached contains a further 139 bins, providing storage for nearly 800,000 bushels. In addition to this terminal elevator, some seventy-two smaller stations, with capacities varying between 50,000 and 600,000 bushels, are being built in the country districts. In every case the main storage consists of reinforced concrete circular bins of 50,000 bushels capacity.

When completed, the scheme will provide storage in New South Wales for the storage of a total of upwards of 15,000,000 bushels of grain.

Concrete Block Buildings in India.—A correspondent in India sends the accompanying views of the fine building which has just been constructed with concrete blocks in connection with the new Revenue Offices at Karachi. The building, which forms the Peons' and Bailiffs' Quarters in the new Public Works scheme, has been built throughout with "Winget" concrete blocks made on their standard machine, with reinforced concrete staircases, flooring, and roofing, and is the largest structure of its type as yet erected in Karachi. Like many other buildings of noble proportions in India this portion of the Revenue Offices affords striking proof of the rapid and economical qualities of this system. We are informed that it was completed, ready for occupation, in seven months—no less than five months less than the time specified in the contract. The building stands on the site of the old jail and consists of a series of 60 quarters, 3 floors high, and 305 ft. in length. The cost was Rs. 1,75,000—equal to about £11,600. The contract was carried out by Mr. J. C. Gammon, of Bombay, represented at Karachi by Mr. S. G. Lyttle, A.M.I.C.E.

Revenue Offices.—Front View.

A Portion of the New Revenue Offices, Karachi.
Back View.—Peons' and Bailiffs' Quarters.

Proper Foundations for Sewers.—At the recent Congress of the Royal Sanitary Institute this question was again under discussion, and some of the speakers seemed to hold the view that under existing conditions the omission of concrete as a bedding for sewer pipes laid at moderate depths was desirable on the grounds of economy. Mr. Palmer, however, the borough surveyor and water engineer of Hastings, expressed it most clearly as his opinion that it is absolutely necessary that sewers should be laid on concrete. Engineers who have had much experience in the laying of sewers and drains know very well that it is no mere fad which demands that sewers should

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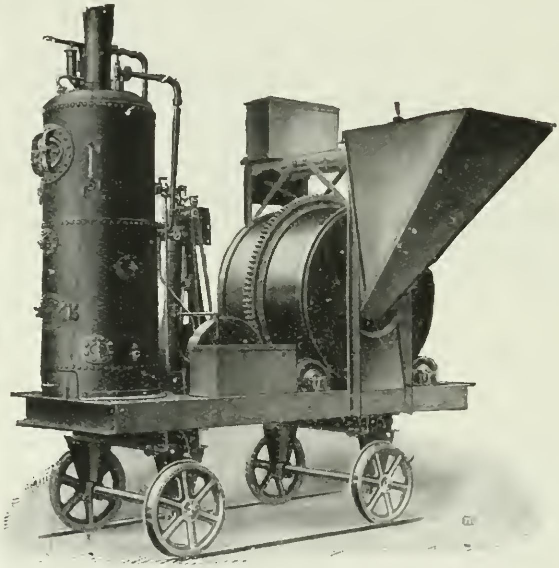

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have proper foundations. Experience has proved conclusively that without such bedding stoneware sewers with cement joints will develop leaks. It is very necessary to warn all concerned against being forced to put in bad work owing to the pressure brought to bear by persons of limited knowledge who imagine that by the saving of material and of an immediate outlay economy is effected. It would not be economical to omit the concrete from the foundations of a building, neither is it economical to omit it from the foundations of a sewer.

The Permanent International Association of Road Congresses.—This Association, whose headquarters are in Paris, is at present organising another Road Congress to be held in Seville in 1922. A number of important questions relating to Road Construction will be discussed at this Congress and there will be a special section, we understand, to Concrete Roads and their construction.

This Association is doing useful work in its endeavours to promote good roads, which they realise are of the greatest importance in the economic life of a nation. There is an increasing necessity for better communication between town and country, and for this a good network of roads is essential. All interested in this problem of good roads should get in touch with the Association with a view to giving it all the support possible. Communications should be addressed to the Secretary at 1, Avenue d'Iéna, Paris.

CONCRETE AND HOUSING SCHEMES.

Blackpool.—The Corporation of Blackpool has passed plans for ninety-four concrete houses, submitted by Messrs. J. Parkinson & Sons, Ltd., to be erected in connection with the Corporation's housing scheme.

Hetton.—The Hetton Urban District Council has obtained tenders for the erection of fifty concrete houses, and these have been forwarded to the Ministry of Health.

Leeds.—The Leeds Town Council has granted certificates under Section 1 (2) of the Housing (Additional Powers) Act, 1919, to the Bowcrete Construction Co. in connection with the erection of four concrete bungalows in Kirkstall Avenue and Boston Avenue, Leeds.

Newton Abbot.—The Newton Abbot Urban District Council has referred to a committee the question of the erection of 104 concrete houses in the Council's area. At the meeting of the Council at which this decision was come to, the Chairman of the Housing Committee showed there was a great dearth of bricks, bricklayers and plasterers in the district, but the houses could be erected in concrete without delay at a cost of about £750 each; they could not be built in brick at anything like the same price.

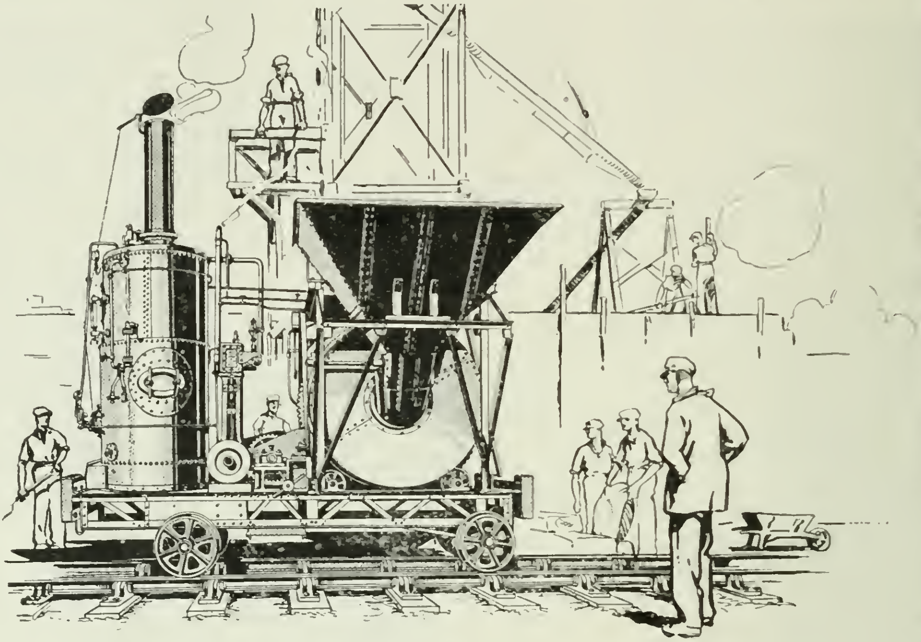
Torquay.—The Torquay Town Council has decided to apply for the sanction of the Ministry of Health to proceed with the erection of 160 brick and concrete houses on the Westhill Estate.

CATALOGUES AND TRADE NOTES

Concrete Structures.—Messrs. Peter Lind & Co., have just issued a new catalogue giving examples of some of the reinforced concrete work carried out by them since 1915. In the preface to this booklet they state that they act as designers and contractors for reinforced concrete work, thus obviating the difficulties and complications which often arise where one firm designs and another carries out the work. The booklet contains some excellent illustrations of work carried out, including workshops, large factories, pile work, etc. Especially interesting are the illustrations of buildings in hand for the Gas Light Coke Company, which we hope to deal with fully at a later date when the work nears completion. Copies of this pamphlet will be sent on application to Messrs. Peter Lind & Co., 2, Central Buildings, Westminster, S.W.1.

C. A. Hunton & Sons have just issued a new catalogue giving full particulars of their Super High-Speed Twist Drills. Engineers and others interested can receive copies from Messrs. Hunton & Sons, 110, Bishopsgate, E.C.2.

Middlesex New Arterial Road.—A New Concrete Arterial Road is being laid by the Middlesex County Council, in conjunction with the Willesden District Council,



The Victoria CONCRETE MIXER

TO preserve the even running of a large capacity Concrete Mixer the utmost care and attention should be given to the method of driving.

In the Victoria the gear teeth and roller tracks are located on a heavy single ring casting placed at the centre of the drum but quite independent of the drum shell. The Victoria Mixer consequently runs smoothly when other types begin to show signs of excessive wear.

The Victoria Mixer is designed and constructed for steady consistent service, and for further particulars please apply for Catalogue M.D. 103.

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connecting Harrow (Main) Road with Brentfield Road, Neasden, and work is now in progress on a $\frac{3}{4}$ mile length. The Reinforcement used for this work is the Walker-Weston (Patent) Pyramidal Double-Layer Reinforcement as manufactured by the Walker-Weston Company, Ltd., Empire House, 7 Wormwood Street, London, E.C.2.

Belfast Tramways.—The same reinforcement is also being used in connection with the contract for the reconstruction of the Belfast Tramways, about 10 miles in extent, which has been assigned to the Consolidated Construction Co., Ltd.

Gravesend Hospital Fête Procession.—The accompanying illustration shows an exhibit by the Associated Portland Cement Manufacturers, illustrating Cement and Concrete in the Gravesend Hospital Fête Procession on June 29. Princess Mary was present on this occasion for the purpose of receiving purses on behalf of the Hospital.

CONCRETE
CEMENT. THE BIG LOCAL INDUSTRY
E186

PUBLICATIONS RECEIVED.

The Artistic Possibilities of Concrete.—This question has been repeatedly discussed in our pages, and has also been frequently referred to in our various technical journals. Nevertheless, it is a matter still calling for much investigation, study and experiment if we are to overcome the prejudices still prevailing against the use of concrete, especially for domestic dwellings.

The little booklet just issued by the Concrete Utilities Bureau under the above title gives some valuable and up-to-date information upon this all-important subject, and should be found useful to all who are interested in concrete construction. The booklet also contains a few coloured plates which demonstrate what effects can be obtained if the right aggregate is employed and the right means are adopted for exposing it.

The pamphlet contains very full and clear instructions how to treat the surface and expose the aggregate. Any one interested should apply to the Concrete Utilities Bureau, 35 Great St. Helens, asking for their booklet No. 14.

PROSPECTIVE NEW CONCRETE WORK.

Alexandria (Egypt).—*Docks.*—A scheme is on foot for the development of the port of Alexandria on a large scale. It is proposed to deepen the Great Pass and construct docks alongside to accommodate vessels 1,000 feet in length, at a total estimated cost of £E.1,400,000.

Bideford.—*Waterworks.*—The Ministry of Health has held an inquiry into the application of the Bideford Town Council for sanction to borrow £41,308 for water supply works.

Birmingham.—*Reservoir.*—The Birmingham Corporation has been recommended by the Finance Committee to expend £25,000 on alterations at Higher Heath reservoir.

Chesterfield.—*Waterworks.*—The Ministry of Health has held an inquiry into the application of the Chesterfield Town Council for sanction to borrow £10,000 for extensions at the waterworks.

Doncaster.—*Sewage Works.*—An application of the Doncaster Town Council for sanction to borrow £39,000 for sewage disposal works has been the subject of an inquiry by the Ministry of Health.

Exmouth.—*Reservoir.*—The Exmouth Urban District Council is considering a scheme for the construction of a new reservoir, at an estimated cost of £5,500.

Glasgow.—*Bridge.*—The Glasgow Corporation is considering the construction of a new bridge over the Clyde, at an estimated cost of £500,000.

Halifax.—*Sewage Works.*—An inquiry has been held by the Ministry of Health into the application of the Halifax Town Council for sanction to a loan of £45,000 for extensions at the Salterhebble Sewage Works.

Hexham.—*Waterworks.*—The Hexham Rural District Council has received the sanction of the Ministry of Health to borrow £3,080 for the provision of a water supply works at Allendale.

Hull.—*Pier.*—The Hull Corporation is considering the erection of a new pier and landing stage, at an estimated cost of £255,000.

Marlborough College.—*Concrete Raft.*—The erection of the Marlborough College War Memorial is to be put in hand at once, and about £8,000 is to be expended this year on the construction of a concrete raft foundation. Mr. W. G. Newton, of Raymond Buildings, Gray's Inn, W.C., is the Architect.

Queenborough.—*Waterworks.*—An application of the Queenborough Town Council for sanction to borrow £7,000 for extensions at the waterworks has been the subject of an inquiry by the Ministry of Health.

St. Helens.—*Waterworks.*—An application of the St. Helens Town Council for sanction to borrow £16,500 for waterworks extensions has been held by the Ministry of Health.

St. Ives.—*Concreting.*—The St. Ives Town Council has decided to proceed with the concreting on the fish-packing plots in Wharf Road, and application has been made to the Ministry of Health for sanction to borrow the necessary money.

Swadlincote.—*Waterworks.*—The Swadlincote Urban District Council has received the sanction of the Ministry of Health to a loan of £5,400 for water supply works.

Taunton.—*Sea Defence.*—The Somerset County Council has received the sanction of the Ministry of Health to a loan of £25,000 for the construction of sea defence works at Taunton.

TENDERS ACCEPTED.

Greenford (Middlesex).—The Middlesex County Council has accepted the tender of Messrs. G. Wimpey & Co., at £10,600, for the reconstruction in reinforced concrete of Greenford Bridge. Seven tenders were received.

Hendon.—The Hendon Urban District Council has received the following tenders for the completion of the sewage disposal works at Renters Lane and the construction of 407 yards of concrete sewer tubes (33 in. diameter), manholes, etc., at Golders Green :—W. Moss & Sons, Westminster, £19,710 3*s.* 5*d.*; Hussey & Egan, Birmingham, £20,254 4*s.*; H. Farrow, Golders Green, £22,720 0*s.* 4*d.*; C. Carter, Golders Green, £23,631 12*s.* 6*d.*; D. R. Paterson, Camden Town, £23,743 12*s.* 3*d.*; G. Wimpey & Co., Hammersmith, £24,092 3*s.* 2*d.*; D. T. Jackson, Barking, £24,329 3*s.* 5*d.*; T. Adams, Wood Green, £25,076 10*s.* 10*d.*; G. P. Trentham, London, E.C., £26,220 8*s.* 7*d.*; Edwards Construction Co., Blackheath, £26,324 0*s.* 7*d.*; J. Cochrane & Sons, Westminster, £27,288 12*s.* 6*d.*; British Construction Co., Westminster, £28,385 4*s.* 6*d.* The tender of Messrs. W. Moss & Sons has been accepted.

Houghton-le-Spring.—The tender of the Adams Housing Syndicate, Ltd., has been accepted by the Houghton-le-Spring Urban District Council for 48 Type " B " houses at £797 15*s.* 6*d.* each, and for 52 Type " A " houses at £701 4*s.* each.

London (Hammersmith).—The Hammersmith Borough Council has received the following tenders for the construction of concrete foundations for pumping plant :—J. Dorey & Co., Ltd., £1,150 ; Higgs & Hill, Ltd., £1,584 ; G. Whimpey & Co., Ltd., £1,650 ; J. Mowlem & Co., Ltd., £1,810 ; J. McManus, Ltd., £1,853 ; Foster and Dicksee, Ltd., £1,920 ; Godson & Sons, Ltd., £1,940 ; Holland and Hannen and Cubitts, Ltd., £1,990 ; Bovis, Ltd., £1,997. The tender of Messrs. J. Dorey & Co., Ltd., has been recommended for acceptance, plus £4 2*s.* per cubic yard for extra depth.

Loughborough.—Subject to the consent of the Ministry of Health being obtained to the necessary loan, the Loughborough Corporation has accepted the tender of the Croft Granite Brick & Concrete Co., Ltd., for the extension of the sewer in Forest Road, for the sum of £1,273. Other tenders received were : W. Moss & Son, Ltd., Loughborough, £1,425 ; W. Lane, Birmingham, £1,530 ; H. C. Pullar & Co., Manchester, £1,535 ; T. Barker & Sons, Loughborough, £1,560 ; A. Sykes, Nottingham, £1,724.

Rotherham.—The tender of Messrs. H. C. Pullar & Co., of Manchester, has been accepted by the Rotherham Town Council for the construction of detritus tanks, reinforced concrete posts, and other work, at Laughton-en-le-Morthen.

Sowerby Bridge.—The Sowerby Bridge Urban District Council has accepted the tender of the Grip Steel Bar Co., Ltd., of Manchester, for the reinforced concrete decking required in the reconstruction of the bridge over the river Calder.

Wanstead (Essex).—The Urban District Council of Wanstead has received the following tenders for the construction of a concrete retaining wall, 80 ft. by 5 ft. :—W. & C. French, Buckhurst Hill, £149 0*s.* 5*d.*; O. L. Loan, Thornton Heath, £145 19*s.* 9*d.*; T. W. Robinson, Greenwich, £220 ; J. Shelbourne & Co., Mark Lane, E.C., £180 ; A. Thompson & Co., Gower Street, W.C., £219 ; J. J. Anderson, Poplar, £169 18*s.* 5*d.*; The Clarwood Co., Ltd., Chancery Lane, E.C., £224 5*s.*; Edwards Construction Co., Blackheath, £204. The tender of Messrs. W. & C. French has been accepted.

TENDERS INVITED.

Bridgend.—August 15. Erection of 10 houses, and construction of roads and sewers (two contracts), for the Commissioners of H.M. Works. Bills of quantities, etc., from H.M. Office of Works, King Charles Street, Westminster, S.W. Deposit, £1 1*s.*

Waltham Abbey.—August 22. Erection of superstructure of a filter house, construction of roads, etc., at Waltham Abbey Pumping Station, for the Metropolitan Water Board. Forms of tender, etc., from Mr. Henry E. Stilgoe, Chief Engineer to the Board, 173, Rosebery Avenue, E.C.1.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 9. LONDON, SEPTEMBER, 1921.

EDITORIAL NOTES.

THE DECORATIVE TREATMENT OF CONCRETE.

ONE of the penalties of civilisation is the growth of self-consciousness; whereas in the past works of art were, for the most part, created as the result of an inward necessity, they are to-day the result of a conscious effort; spontaneity is to some extent replaced by deliberation. Nowhere is this more clearly seen than in architecture, where the constant talk of *styles* shows that the attitude of the designer towards his work is largely one of eclecticism. A duality has crept into the larger architectural works, necessitating a structure and a covering for the structure, and the selection of this covering has become almost as definite a matter as choosing a pattern for a new suit. In addition to the growth of self-consciousness there is another force operating to bring about this so undesirable result. Two minds are now required instead of one to produce a large building; those of the architect and the engineer. This is inevitable, it is a difficulty that must be faced, and will yield satisfactory results only when the two minds work in harmony, each realising its own limitations and respecting the knowledge, training and experience of the other.

This month we publish the first of a series of illustrated articles by Mr. Godfrey E. Page, A.R.I.B.A., dealing with this matter in its application to concrete. The first article shows how each new constructive discovery has two phases, "the first purely utilitarian, the second highly decorative." The application of this generalisation is shown by means of two examples of arcuation, one primitive the other complex. In subsequent articles the author will show how proper collaboration between the architect and the engineer, each equipped with his special knowledge, may bring about changes in the design of concrete buildings. In this way a real and intimate connection between the construction and the ornament may be looked for.

At present there exists an antagonism between the engineer and the architect, and, it must be admitted, this is largely the fault of the latter, who has adopted a persistently reactionary attitude towards concrete instead of welcoming it as a material which is capable, with intelligent treatment, of yielding the most beautiful results. Huge voids may be roofed and mighty distances spanned, in a manner that would have amazed the Gothic builders straining under the limitations of arcuation and the difficulties of thrust and counter thrust.

We feel that it is essential that the interest of the architect be aroused and his imagination stirred by the great possibilities which concrete holds, similarly it is essential that the engineer be made to realise that the contribution of the architect is real and vital. The æsthetic needs of humanity must be supplied, and the architect is the person who is most fitted, both by disposition and by training, to supply them. Our object is, therefore, to establish a closer *liaison* between these two, so that they may work together in harmony for the ultimate benefit of mankind in producing fine and noble buildings, serving the requirements and satisfying the æsthetic demands of civilisation.

THE COST OF HOUSE BUILDING.

THE height to which the cost of building dwelling-houses soared after the war, and especially after the inauguration of the Government housing scheme, has been the subject of exhaustive inquiry by Committees appointed in England and Scotland, which have now issued their reports. Both Committees were composed of architects, surveyors, builders and operatives, and the recommendations made are substantially the same in both cases. Briefly, the findings are as follows :—The high cost of labour is blamed as the principal cause of the high cost ; the financial basis of the Government scheme, by which the liability of the local authority is limited to a penny rate, has been responsible for a good deal of extravagance, and the launching of such a large scheme, to be completed within three years, caused congestion in the industry and tended to force up prices.

In the report of the English Committee matters which so vitally affect cost as the adoption of cheaper methods of construction, the use of labour-saving machinery and methods, and organisation are either not touched on at all or only mentioned in passing, but it is in these directions, we think, that the building of dwelling houses at an economic price is most likely to be brought about. Could not a committee be set up, composed of unbiased practical men, to consider and report on these matters, and give figures of savings effected by the use of new materials and improved machinery ? Such a report, by showing in actual money value the savings that we are convinced can be made, would provide a basis on which the return on the capital outlay could be assessed and would be of considerable value. A great deal can be done towards cheapening building by organisation, not only on the job but in distributing the work over the whole year. This, of course, would involve enlisting the help of the public, who have the deciding voice as to when their work shall be carried out, but do not always realise that nowadays much work that was formerly looked upon as only possible in the summer can be carried out at any time of the year. For instance, with adequate protection and by keeping up the temperature of the materials reinforced concrete work can be executed in the severest weather without detracting from its ultimate strength. Much of the unemployment in the winter which occurred in the past could have been avoided if the work had been more equally spread over the whole year, and the avoidance of a " rush " period in the summer would have resulted in reduced overhead charges.

We are glad to see the Committee recommends that normal competitive conditions be returned to as soon as possible, and now the Government has, to all intents and purposes, abandoned its housing programme we presume this will naturally come about. This will mean that houses will have to be built at such a price that they can be let at an economic rent, and, at the same time, give a reasonable return on the capital invested. Already the prices of such houses show a reduction of as much as one-third compared with prices ruling six months ago.

A considerable amount of space is devoted to labour problems, and especially to the low output per man, but no definite conclusions seem to have been arrived at ; this subject is, in fact, side-tracked with a recommendation that a further committee be appointed to consider it. The necessity for increasing the available supply of skilled labour is realised, and this, the Committee declares, is a fundamental step to the cheapening of the cost of building. No suggestion is put forward for augmenting labour, as the Committee thinks this is a matter best left to the industry itself.

With regard to materials, the Committee expresses the opinion that there has been no profiteering, although there may be a tendency unnecessarily to keep up prices now. " High water-mark in materials has," it is stated, " set in, and with more normal conditions prevailing and an improved supply a downward tendency has set in, and it is thought that in the near future prices of materials will reach a reasonable level."

So far as they go, we are in agreement with the findings of the Committee, but a great deal has been left unsaid. Perhaps it was outside the scope of this Committee, but an investigation along the lines we have indicated would, we are convinced, be of great service to the industry.

OUTPUT IN BUILDING WORK.

Many large building schemes are in abeyance at the present time owing to the high cost of building work of all kinds and yet considerable unemployment exists. The majority of architects and engineers have schemes which are all planned, detailed and prepared, but clients are unwilling to proceed until some future date when conditions are more settled and prices are reduced. It is true that wages have a downward tendency, but the complete solution of present difficulties will not be found by a reduction of wages alone.

The cost of housing work is of course influenced by several factors, many of which are outside the control of the general contractor and ordinary worker, as the Government control has introduced a system that is not conducive to competitive work either in material or labour. There is, however, a large amount of building work of an industrial nature which would be proceeded with if the promoters could see the work executed at a price which would show a fair value for the money expended.

This does not necessarily mean a large reduction in wages so much as an increased output by each organisation and each individual of that organisation.

As an example we have only to consider the wages in other countries and see how these compare with those prevailing here. Until a few months ago when the English bricklayer was earning 2*s.* 4*d.* per hour, the American bricklayer was being paid $1.25 per hour, which is equal to 5*s.* 2½*d.* at the normal rate of exchange, and considerably more at the present rate. Other skilled trades are paid in comparison and yet America can compete with this country in the markets of the world despite the fact that the workmen are paid over twice as much in wages.

The whole secret lies in the fact that the output per man is considerably higher, as while the bricklayer in this country has laid from four hundred to six hundred bricks per day, the American bricklayer has been laying from one thousand to twelve hundred in the same time, and thus an equivalent value has been given and, in addition, increased speed has been achieved. We do not make the comparison with the idea of suggesting that the output in this country is deliberately restricted but rather as an illustration of the possibilities provided the workers are willing to put forward increased effort and employers are willing to assist this effort by the adoption of modern methods, while at the same time recognising the right of the worker to share in the fruits of his labour. It is an appeal to workers and employers wherein a comparison is made to support the contention that it is possible for all parties to benefit by increased output if the right spirit prevails, and undue advantage is not taken of the worker by the employer as has been the case far too often in the past. We were interested in one scheme where it was extremely important during the late autumn last year to erect a large boiler house the lower part of which was of reinforced concrete and the upper part was of structural steel encased with brickwork. The total number of bricks to be laid was just half a million, and with the aid of sixty bricklayers the whole of the walls were built in seven working days, meaning an average of twelve hundred bricks per man per day, and the whole of the work was built overhand from swinging scaffolds, the maximum height of the walls being about 90 ft. from the ground. Two days after the work was completed a heavy snow storm occurred which resulted in 18 in. of snow in twenty-four hours, and it was only the rapid erection which saved the situation.

A great deal naturally depends on the organisation as a whole, because the individual output must suffer if supplies are not readily forthcoming and continual delay has to be encountered by skilled and unskilled labour, and it must be a admitted that, even to-day many of our methods are antiquated and obsolete; but on the other hand unless the individual will take advantage of the facilities offered by a good organisation where it exists, and modern appliances where they are employed, then the best results cannot be obtained. In the erection of structural steelwork in America also the output per man is considerably higher than is the case in this country and, consequently, higher wages can be paid and better speed achieved.

We do not propose to make any statement as to the value of trade unionism and its effect on output and wages, but in America it is possible to appeal to the men's official delegates to speed up the output, and in one instance where a date had been given by the contractor for the erection of some steelwork, and some unavoidable delays had occurred in the early stages, the superintendent in charge of the work approached the union delegate and told him that as it was a union job he expected better results, and he wanted an output of 200 per cent. out of all the steel erectors for the following fourteen days, and it was the delegate's mission to expedite the men and see that the result was achieved. It is interesting to note that the delegate actually did expedite the work, and he materially assisted the superintendent in executing the erection in a very short time.

The trade unions in this country are far better organised than those in America, and if they can speed up output while at the same time protecting the interests of the workers, the result will be beneficial to the building industry and the whole community.

It is a mistaken idea that is prevalent among the majority of workers that increased output will result in less workers being employed and, consequently, more unemployment will follow, whereas the exact opposite should be the case provided the proper relationship exists throughout the industry. If a good output is obtained the person supplying the capital can proceed with many schemes on a profitable basis which would otherwise not be worth while, and obviously each scheme that is put in hand means more employment.

It also follows that good output is a prime factor in any successful business and successful business is inevitably followed by expansion of operations. The worker who uses the raw materials in building work is very much affected by the output of the men engaged on the preparation of these raw materials, while the output of the men engaged in the erection of the main structure has considerable effect on the trades employed in the finishings, and so the work in each trade will influence the amount of employment in other trades which are allied.

In the case of concrete work the question of output is of the greatest importance, because it affects the workers in the actual trade even more than it affects other branches.

This will be realised when it is understood that in many instances concrete is in competition with other forms of construction and, apart from any question of merit, it will be adopted only when it is economical in cost. Many instances could be given where concrete has been adopted for walling, because the small output of the bricklayers has rendered the use of brickwork prohibitive, and the contractor has been able to quote a lower price for the concrete work. In other cases the inefficient organisation and small output of the workers, has rendered concrete more costly than brickwork and the latter has been used. This should be sufficient illustration to show that the output in many trades, and especially in concrete work, will influence employment in a very different manner to that which many workers have in their minds at the present time, viz., that increased output will result in more employment and a more prosperous era for the workers rather than less employment as many fear.

In the case of concrete construction, the question of output is of vital importance as it will have considerable influence on the extent to which the material is adopted for many large schemes in the near future, and yet it is somewhat difficult accurately to measure the output per man, because many factors are involved which must be considered when preparing data. The output of an individual bricklayer is a simple matter to estimate, but with concrete work it is the output of a whole organisation which has to be gauged. It is here that the opportunity for the good organiser arises, and the cost of concrete construction is affected by the general organisation far more than is the case with any other trade in building work. The reason for this is quite clear if we consider how the work is executed by a sequence of operations that are related to one another in such a manner, that a weakness in any one operation will reduce the output of the whole system. The form erection must be well planned and kept ahead of the laying of the reinforcement, the latter must not hold up the placing of the concrete and in the making of the concrete the raw material must be properly supplied to the mixers, and the transport of the mixed concrete must be well conceived and handled.

Many concrete mixers are capable of turning out a cubic yard of concrete per minute, but how many schemes are sufficiently well thought out to permit of this quantity being transported to the placers in such a manner that it can be properly deposited and tamped in the work ?

The maximum output is seldom attained because there is some weak link in the system which governs the speed of the whole organisation and reduces the output even when the individual units are imbued with the right spirit, and are willing to give the best possible return for wages paid. The future of the concrete industry therefore, unlike many other trades, is largely in the hands of engineers and contractors, because the necessary output, which will ensure its success in the face of competition with other structural materials, can only be attained when the initial organisation is good, and the use of suitable and necessary appliances and machinery is arranged. Concrete will obviously hold its place as the ideal material for use in many of the features in the construction of industrial buildings, but there is a possibility of its use being considerably restricted, if the cost is not kept down to the lowest possible limit.

We have long since passed the experimental stage in the use of this material for any part of a structure, and even the most conservative architects and engineers now realise the value of this material, which possesses qualities of fire-resistance, adaptability and permanence unequalled by any other and which can be manufactured on the site and moulded to any desired form. There is a danger, however, at this time, of a reaction taking place which will retard the adoption of concrete, because the question of price is the one deciding factor, and restricted output means enhanced price, therefore too much attention cannot be paid to this point. Concrete work can be executed speedily and economically and, if properly organised, the cost will always be lower than that of any other structural material, unless no aggregate is available in the vicinity or there are some special circumstances which set up a serious handicap against its use. An illustration of the speed which can be attained by reinforced concrete construction is that provided by a large warehouse erected in the United States last summer. This warehouse, which is four stories high, contains eight acres of floor space and it necessitated the placing of over 16,000 cubic yards of concrete ; while the whole building was erected in fifty-five working days of eight hours each. Only two mixers were used, but as the output from each machine was on many occasions as high as 432 cubic yards per day, and the work was organised to permit of this amount being placed, it will be seen that there was no weak link in the chain of operations, and the output of the whole organisation was good. The most serious question in the whole of the industrial world, at the present time, is that of output, because limited output means high prices, high prices mean unsaleable articles, and unsaleable articles mean bankruptcy. Concrete construction will become unsaleable if prices rule higher than that for other materials answering the same purpose and its use will, therefore, become very limited. Quality must of course be maintained, and economy effected through loss of quality either by poor design or execution will seriously react on the responsible parties, and thus the real solution of present high prices is in output both of the individual and the whole organisation. Obsolete and costly methods of handling materials should be eliminated, the natural advantages of any scheme should be thoroughly studied, and full use should be made of suitable equipment for every stage of the operations.

Reliable data should be prepared by every contractor, which would indicate the output in a useful form so that improvements could be made from time to time, and thus ensure the lowest possible cost which would give a fair profit. We are now at a critical stage in our post-war problems, the building industry is in a position which is fur from prosperous, and every effort must be made to restore prosperity.

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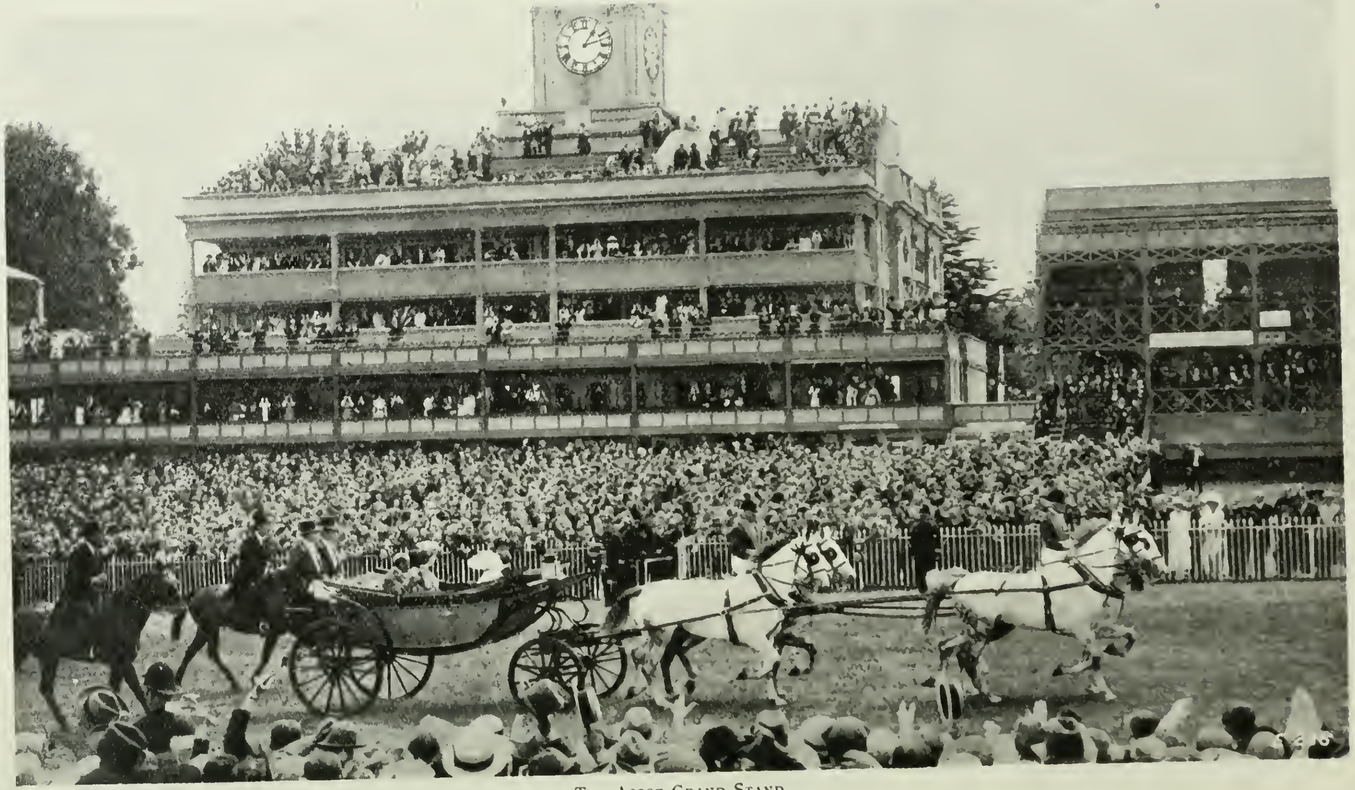
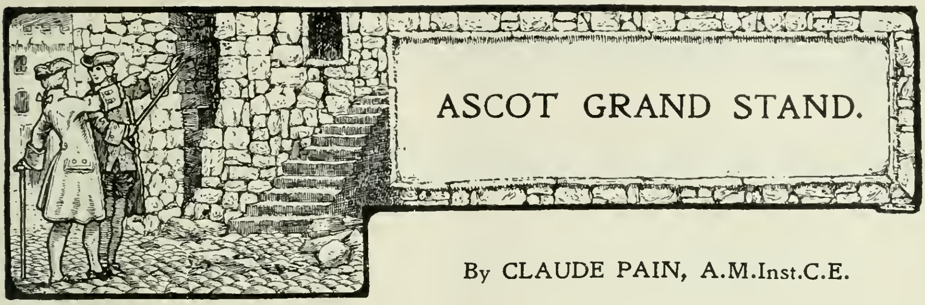


THE ASCOT GRAND STAND.
(For description, see page 565.)



ASCOT GRAND STAND.

By CLAUDE PAIN, A.M.Inst.C.E.

SHORTLY after the Ascot race meeting in June, 1919, it was decided to partially reconstruct the Grand Stand, which was originally built in 1839, to bring it up to date with modern requirements.

The frontispiece shows the stand as it now appears after reconstruction. The building is about 97 ft. long by 60 ft. deep, and the top of the roof stand is about 50 ft. above ground level. It is divided into front and back portions by a main middle wall, the back half being occupied by a main and two side staircases and lavatories, with clock tower over, while the front half is devoted to stands and private boxes. It was decided not to interfere with the lower tier of boxes, which project in front of the main building, but to replace the two then existing stands by two upper tiers of boxes with dining-rooms immediately behind and a main roof stand over. Later, additional dining-rooms were added in the back portion of the building and the old timber roof was reconstructed to carry a large water storage tank and several subsidiary tanks.

Nine months only being allowed for the demolition and reconstruction work, including re-decoration, and it being desired to make the structure fireproof, it was decided to utilize a steel framework with precast reinforced concrete floors and balustrades, mac slab partitions, and ceilings of expanded steel lathing and plaster.

Immediately the 1920 June race meeting was over, the contractors commenced demolition, including the removal of six 30-ft. main cast iron girders, and in the meanwhile the making of the precast concrete floor sections was proceeded with, so that as the steel framework was erected the successive floors could be laid and the partition work proceeded with. It speaks well for the efforts of those concerned that, despite labour troubles, the work was completed in little over the allotted time.

The ground floor of the front half of the building was occupied by large tea and refreshment rooms, the ceiling being supported by the cast iron girders previously referred to spanning from the middle to the front wall of the building. These girders, being of insufficient strength to carry the new work, were replaced by a similar number of compound joist girders and upon them the upper portion of the new work was carried as shown in *Fig.* 1. While the main girders were being substituted the ceilings of the tea-rooms below were underpinned until such time as the ceiling joists could be suspended from the compound girders by means of wrought iron hangers, thus avoiding destruction of the inter-

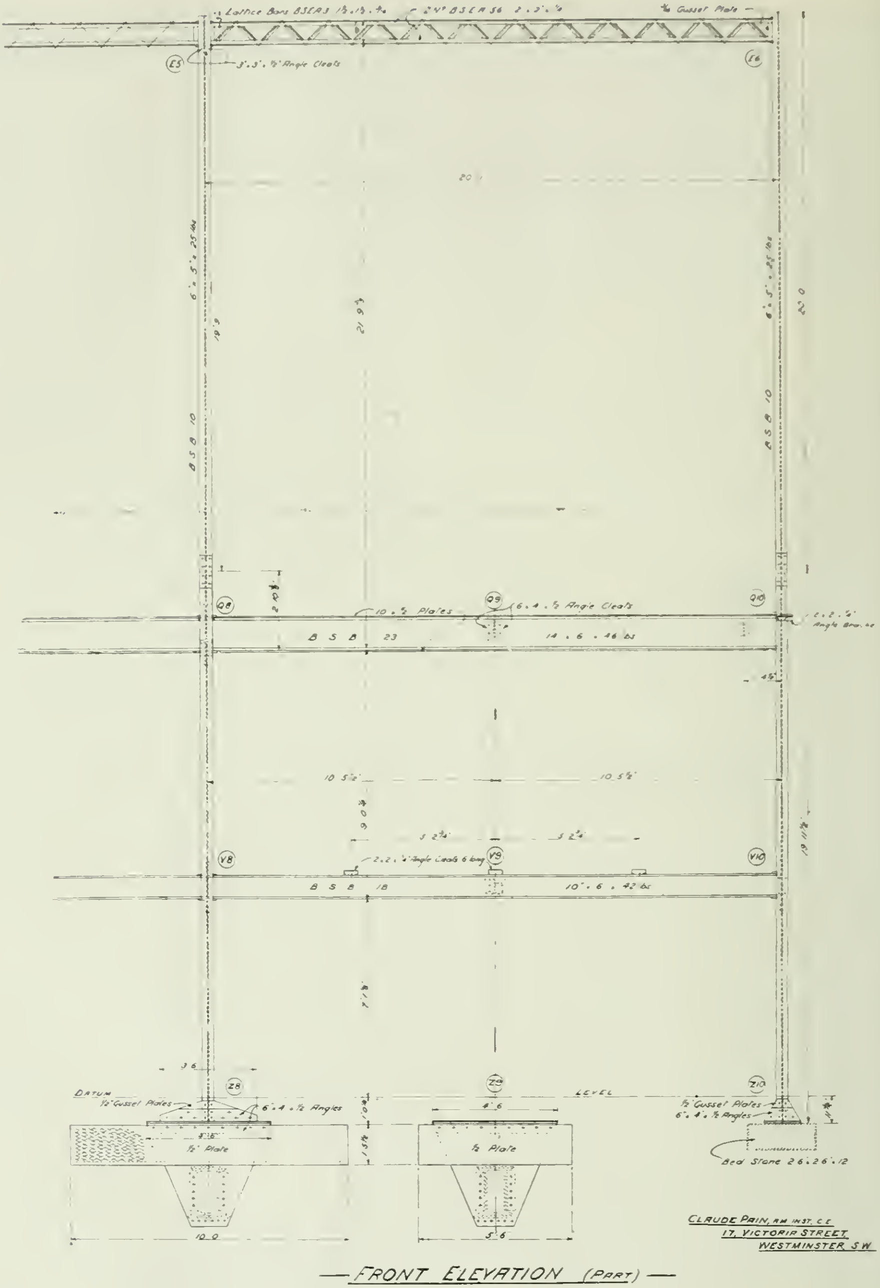
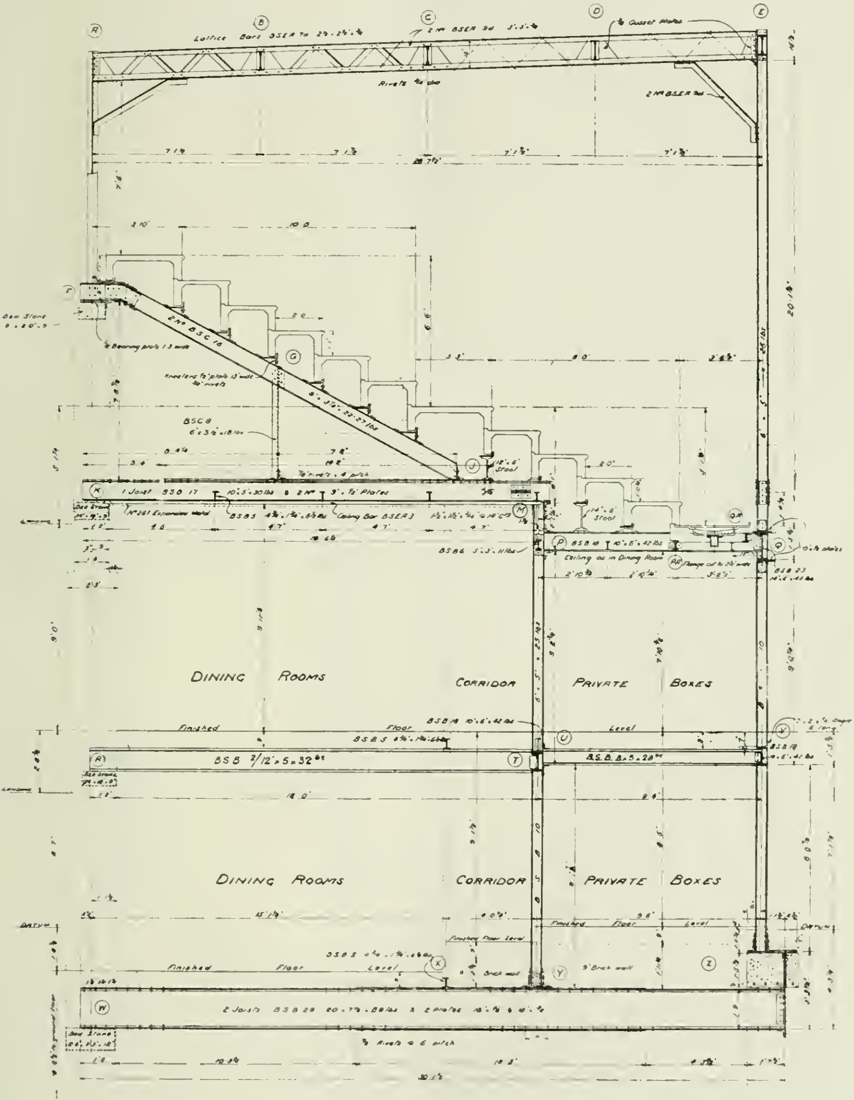


FIG. 1 (PART) GRAND STAND, ASCOT.

nal decorations below. The weight of the main girders was distributed on the external 27-in. wall by means of slotted reinforced concrete grillage beams, from which they were suspended by a special sling plate. This method was adopted to avoid the interference with the decorations of the ground floor rooms, which would have been occasioned if the grillages had been placed below the main girders, and they also gave direct support to the bases of the front row of stanchions.



— SECTION AA —

FIG. 1. GRAND STAND, ASCOT.

The inner ends of the main girders were originally arranged to rest on the

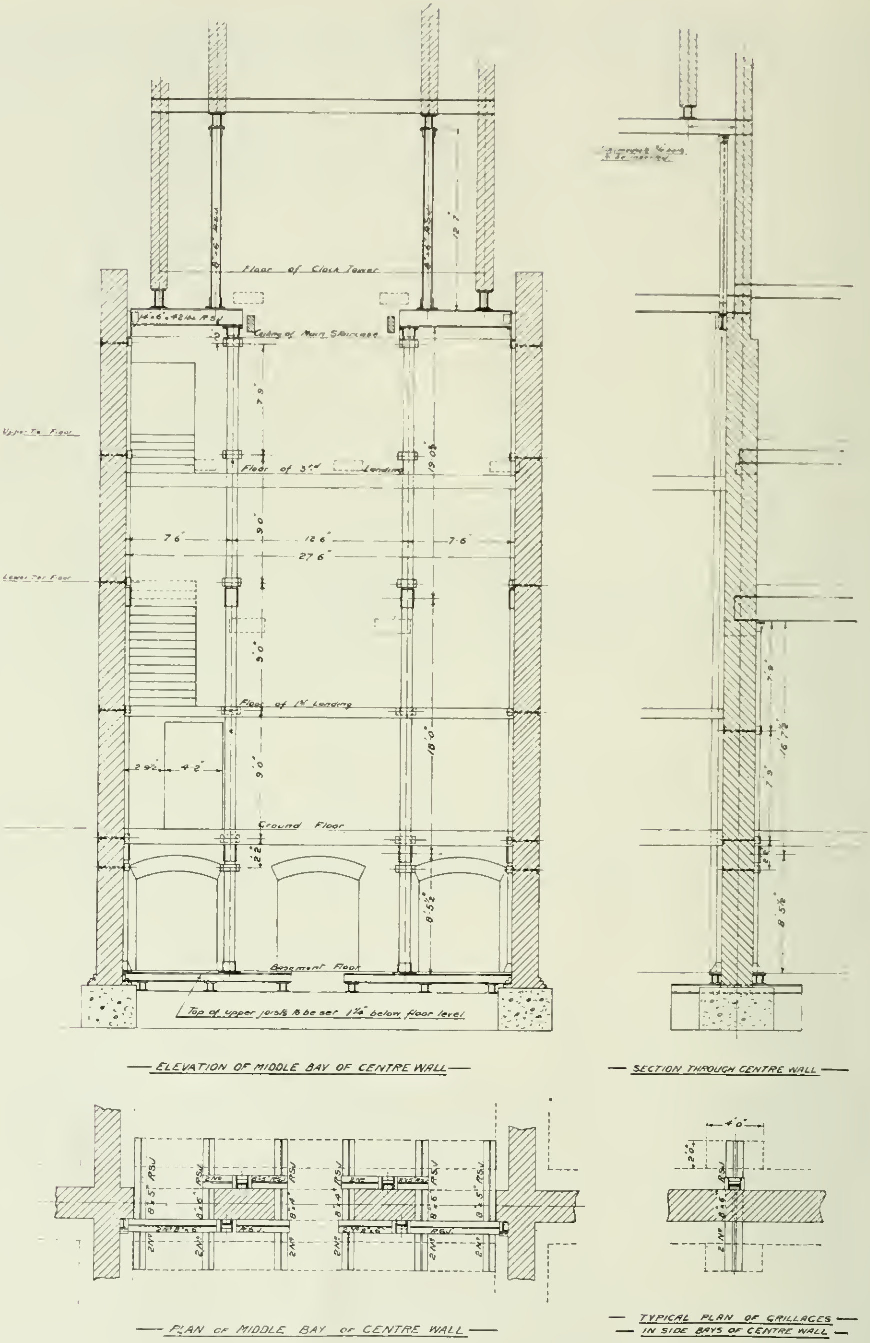
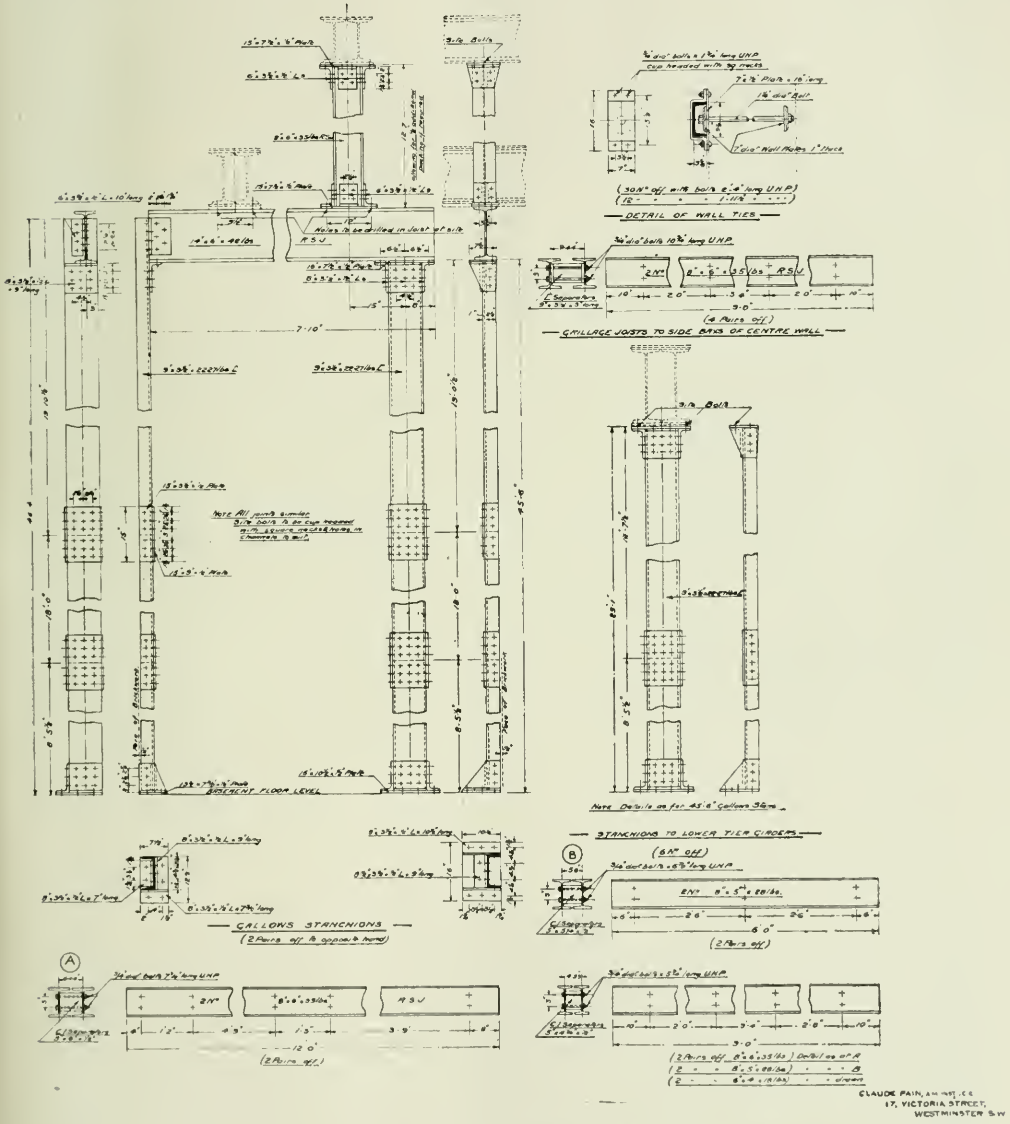

Floor of Clock Tower
14" x 6" x 42lbs R.S.J.
Ceiling of Main Staircase
Floor of 3rd Landing
Floor of 1st Landing
Ground Floor
Basement Floor
Upper Ter Floor
Lower Ter Floor
7' 6"
12' 6"
7' 6"
27' 6"
7' 9"
9' 0"
19' 0"
18' 0"
12' 7"
2' 2"
8' 5½"
16' 7½"
Top of upper joists to be set 1¼" below floor level
ELEVATION OF MIDDLE BAY OF CENTRE WALL
SECTION THROUGH CENTRE WALL
PLAN OF MIDDLE BAY OF CENTRE WALL
TYPICAL PLAN OF GRILLAGES IN SIDE BAYS OF CENTRE WALL
4' 0"
2' 0"
R.S.J.

FIG. 2. STANCHIONS TO CLOCK TOWER, GRAND STAND, ASCOT.

middle 27-inch wall, but after a test had been made of the crushing strength of the brickwork, and in view of its age, it was decided to carry stanchions down to basement level, 25 ft. below, and to spread the weight on specially constructed foundation grillages. At the same time the weight from the girders carrying the Clock Tower, which also rested on the middle wall, was transferred on to stanchions erected upon the same grillages as shown in *Fig.* 2. The latter stanchions being 45 ft. long were stayed through guides, bolted to the middle wall



Part of Fig. 2. Grillage Joists to Middle Bay of Central Wall.

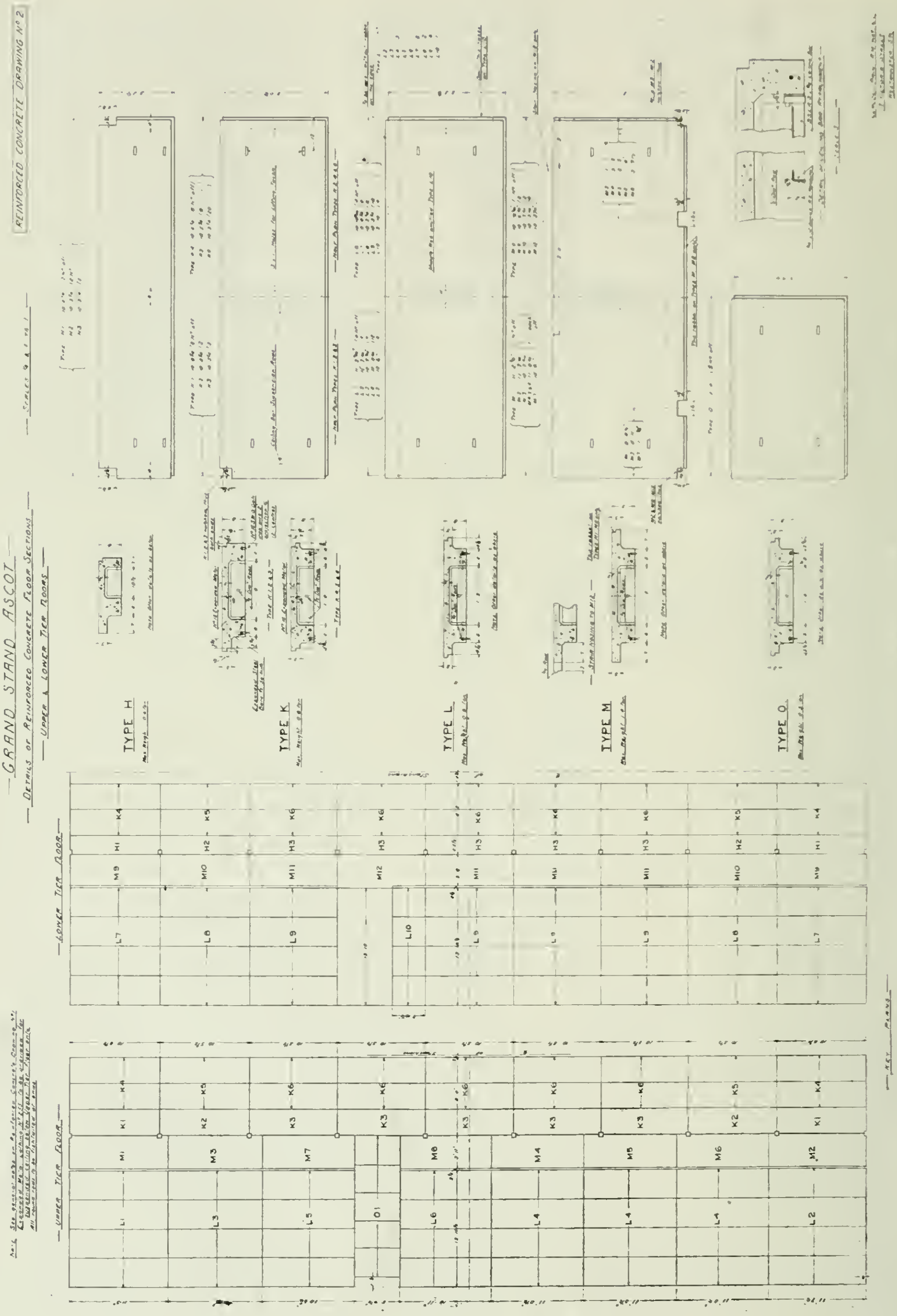


Fig. 3. Details of Reinforced Concrete Floor Sections, Grand Stand, Ascot.

at intervals of 9 ft., in order to reduce their size and ensure the weight being transmitted to the foundation. The weight, calculated to be borne by these stanchions, was imposed by wedging from the top ends and after a preliminary squeeze had been given by means of jacks to make sure that the joints were well butted, the actual weight on the stanchions was deduced from the alteration in the length of the stalk under the influence of the wedging.

The roof stand will accommodate about 2,500 densely packed people, and careful provision was made in the calculation for the effect of surge by the provision of horizontal diagonal sway bracings to transmit any tendency to lateral movement to the middle wall. *Fig.* 1 shows provision made for a canopy to the top stand, but this was subsequently omitted.

Fig. 3 shows the details of construction adopted for the precast reinforced concrete slabs for the floors of the upper and lowei tiers. The steps for the roof stand were of similar design and the several types required were so arranged that alteration of the moulds would be reduced to a minimum. A specially designed lifting yoke was used to avoid wracking while hoisting and setting the sections into position. The accuracy and care with which the work was carried out is testified to by the fact that not a single section was faulty or damaged and that, although only ¼-inch joints were allowed, all sections fitted correctly into position without having to be dressed down.

The first floor section to be cast was tested at six weeks old, supported at each end and loaded at the third points. It carried an ultimate load equivalent to 6¼ times the distributed working load for which it was designed. The roof stand was covered with asphalt to render it weatherproof and the internal floors were covered with patent jointless flooring composition.

The structural steel and reinforced concrete work was designed for the architects, Messrs. Hunt & Steward, by the Author. The contractors were Messrs. Higgs & Hill, Ltd., who obtained the steelwork from Messrs. A. D. Dawnay & Sons, and the crushed Thames ballast for the aggregate from Messrs. Wm. Boyer & Sons.

MEMORANDUM.

Arch Design and Construction.—Investigation now in progress at the engineering college of the University of Illinois is an attempt to throw more light on the intricacies and complexities of arch construction and design. The first experimental arch at the middle-western university is now being tested. It is a reinforced concrete 30-foot span arch with a 6-foot rise, is 3 ft. thick, 6 in. thick at the crown and 15 in. thick at the abutments.

The engineering experts are endeavouring to establish definitely the truth or fallacy of the three theoretical assumptions which long have been accepted as fundamentals—that in the case of an arch under load : (1) there occurs no change in the length of the span ; (2) no change obtains in the elevation of one support with reference to another ; and (3) no rotary motion of either abutment ever results.

The investigational arch is also under test for spreading and weakening of the abutments when the loads are increased and applied at different points.

NORTH CIRCULAR ROAD, WILLESDEN (SECTION No. 1).

In contradistinction to the Southwark roads, which are essentially hand-made, this road may be said to be almost machine-made. The machinery in use has been supplied by Messrs. The Allied Machinery Company and, although this type of road construction has been used very largely and with success in the States, it is one of the first occasions on which the system has been employed in this country. It is acknowledged that conditions in America are very different from those prevailing in England, both as regards long stretches of roads unbroken by villages, and the degree of perfection in the work demanded by those in authority. It will therefore be seen that the Willesden road constitutes a good test as to the advisability of using American methods of concrete road construction in this country.

Method of Preparing Foundation.

The section of road under construction is approximately one mile long and 24 ft. wide. For two months the subgrade, consisting of 6 in. of burnt ballast, has been laid and rolled with a steam roller. Working roughly 150 ft. in front of the mixer, the subgrade receives its correct camber and the side forms, which also form the rails on which the finishing machine travels, are placed in position. Every 10 ft. two bricks are " boned " in along the sides of the road, and the side forms are laid on the bricks and secured to the ground exactly the same distance apart throughout, viz., the gauge of the road-finishing machine.

Every 20 ft. crown pegs are " boned " in 3 in. higher than the top of the side forms, which are 8½ in. deep. Quarter pegs are " boned " in 1½ in. higher than the side forms, thus a true camber of 3 in. is maintained. Just before the concrete is laid, the subgrade is well watered and hand-rolled.

No provision is made for a " fall " draining water off the road, except the natural cross fall, and the gradient of which the average for the mile is one in 230. On each side of the road will be a green sward, and it is under these that the gullies will be situated, covered by a chequered plate.

Placing the Concrete.

The position of the mixer is in the middle of the road and travels backwards by its own power on a sleeper track. Skips containing the aggregate are run up past the mixer, but not on the subgrade. An arm attached to the mixer lifts the skip bodily from its chassis and deposits the load in a shoe ; this is hoisted in such a way that the mixture of aggregate and cement is shot into the revolving drum. The water is then added without any preliminary dry mixing. From here the concrete passes into a bucket, which travels along a boom suspended from the mixer. This boom can be swung from one side of the road to the other, the concrete being dumped where desired by releasing a catch, whereupon the concrete falls through the collapsible bottom of the bucket.

The road is being laid on the two-course system completed in 6 ft. bays. The following is the method of procedure. Firstly, a thin layer of concrete is placed on the subgrade right across the road and 6 ft. in length ; this is only to embed the reinforcement which is 5 in. thick, made by Messrs. Walker Weston, details of which it is not necessary to give. On top of this is laid 5 in. of the first mix proportioned five parts of pit ballast, graded from ⅜ in. to 2 in., to two and a half parts of pit sand to one of cement. This is spread over the bay by three men, who shovel it from the heaps where it has been dumped from the mixer. At once this is covered by 3 in. of the second mix proportioned three parts of ⅜ in. pit sand to one of cement.

The concrete is much sloppier than that used on the Southwark roads, and under the circumstances this is probably necessary. The Walker Weston reinforcement is intricate and, if a very stiff mix was placed on it and not rammed well by hand the resultant concrete would be so full of voids and unfilled spaces that many small pot-holes would be found in the road after heavy traffic had been over it for some time. The total depth of the concrete now is 8½ in., which brings it, at the edges, to the level of the top of the side forms.

Now the road-tamping machine is brought into action; it travels very slowly along the top of the side forms and has two wooden vertical planks stretching from side to side and cut out to the camber of the road, thus forming a template. The first of these has a lateral movement of about ¾ in., and pushes the surplus concrete in front of it, the second is the tamper and has a vertical movement which can be adjusted slightly. This template is about 1½ in. thick, and strikes any one point in the road about five blows before passing on. The machine is worked over the bay four or five times. Each time it goes back the spreaders place some more concrete on the slack places which the tamper did not touch. When the road was first started the top layer was placed on the bottom course in such a way that at the end of each bay both edges presented a vertical face, but it was found that when the road finisher tamped the concrete at the end of the bay it caused a depression which was hard to rectify. The difficulty was overcome, however, by laying the top course in such a way that it was always 6 in. behind the bottom course at the end of the bays; this incidentally forms a good key at the beginning of a fresh day's work after the section has been watered well.

Levelling Formation of Road.

Road in Course of Construction Showing the Reinforcement.

A section of this road has been completed on the one-course system as an experiment, the large aggregate graded down to ⅜ in. being used on the surface as well as below. It will be interesting to notice how this section fares compared with the rest of the road after it has been opened to traffic.

CURING.

The day after the concrete has been laid, waste material, mostly sand, is spread over the work to a depth of 1½ in. This is watered every day for a month, at the end of which time it is picked up. The road will be given a coat of tar, but it has not been settled how long to leave it before this is done. However, it is understood that no tar will be put on until the concrete has had at least two months to cure and harden.

SECTION CONCRETED AND COVERED.

CONCRETE SECTION COMPLETED—UNCOVERED.

TIME AND LABOUR.

For the first few days no more than 800 cu. ft. were laid in a day, or 50 ft. run. This, however, has been improved upon, the record up to date being 1,184 cu. ft., or 74 ft. run.

The labour for the complete job is detailed as follows :—

1 man spreading curing material and watering.
1 ,, pumping water.
4 men striking side forms and preparing subgrade.
6 ,, setting ,, ,, ,, ,, ,,
3 ,, levelling concrete.
2 ,, tipping cement in mixer.
2 ,, ,, ballast and sand in mixer.
3 ,, driving (2 on mixer, 1 on road-finishing machine).
1 brakesman on skip road.
5 men loading into skips.
2 ,, bagging in cement shed.
2 ,, gangers.
2 ,, setting manhole covers.
1 mess room man.
1 man on wharf watching ballast and sand.
2 night watchmen.
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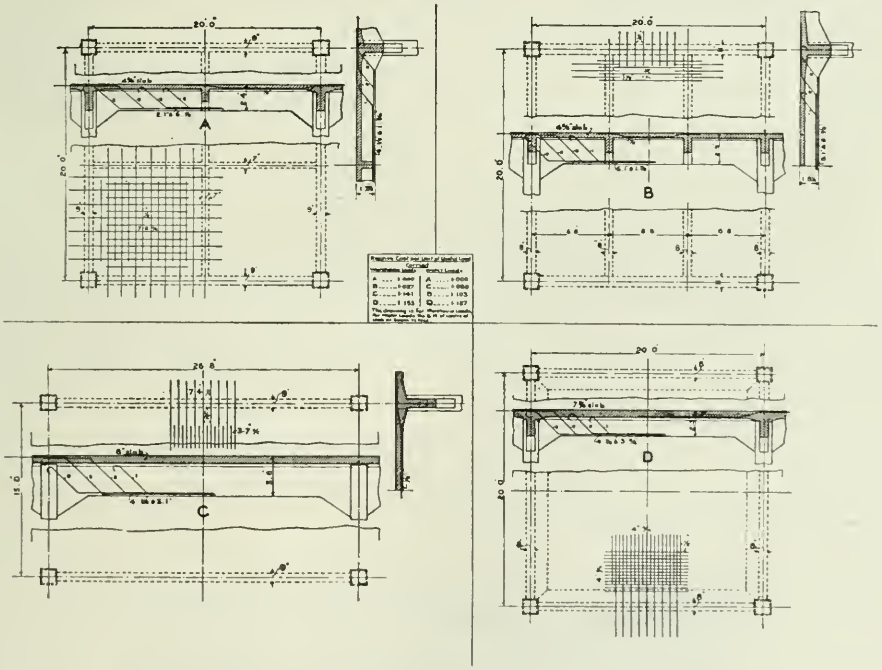
REINFORCED CONCRETE FLOOR TYPES

By W. H. THORPE, Civil Engineer.

Being anxious to determine the difference in economy of various floor layouts the author has prepared detailed designs of the four types illustrated, each bay supporting 400 sq. ft. of floor surface. The total load carried was taken at 330 lb. per sq. ft., inclusive of floor, care being taken to assure the same unit stresses for each type throughout in order that the comparison might be fair to each.

Type of R.C: Floors to carry 330 lbs. per sq. ft. total—Area supported = 400 sq. ft.



Quantities and cost were then determined, and the useful load carried having been ascertained, the cost in shillings per 1,000 lb. of useful load was calculated. It should be explained that pre-war costs were assumed, on the supposition that prices are now, or will eventually be, proportional to the pre-war standards.

The four types have been considered for multiple spans, as applied to floors which may be irregularly loaded, as for warehouses, in which case the slab and beam strength at the centre of a span may equal, or be nearly equal, to that at the bearings, and also for loads always uniform, as in elevated reservoir floors, for which the centre moments may commonly be but one half that occurring with irregular loading.

The ruling stresses are :—

Concrete	600	lb. per sq. in.
Steel in tension	15000	,, ,, ,, ,,
Shear in Concrete (no shear members)	75	,, ,, ,, ,,
Shear in Concrete (with shear members)	150	,, ,, ,, ,,
Shear in Concrete (in T wings, with steel)	100	,, ,, ,, ,,

The unit prices are :

Concrete—in place	1*s.* 6*d.* per c. ft.
Steel—in place	1·5*d.* per lb.
Shuttering—vertical	4·5*d.* per sq. ft.
Shuttering—horizontal	3½*d.* to 2¾*d.* per sq. ft.

The results are tabulated in order of economy.

The unity rate (i.e. the minimum) for each description of loading is not intended to indicate equality of cost, the cost being as a fact less for water loads than for warehouse loadings.

For different areas and loads carried the order of economy would probably remain the same, though the economic ratios would perhaps differ in some small degree, favourably in the case of types C and D for lesser standard loads, or areas supported.

MEMORANDUM.

A New Method of Moulding Concrete Under Water.—This method (the patent of John Stow, Christiania) consists of a light, strong and flexible covering such as canvas, provided with filling hose, lowered emptied to its place and anchored. The liquid mortar is then filled in. Steel reinforcing is sewn in which rises in place during filling. Straps or ropes are sewn in the moulding cover in order that the concrete may acquire the desired shape. The filling should take place under some pressure. For standing castings and those that extend above the surface of the water reinforcements may be put in place during the operation.

Waterfilled hose has also been used for damming shallow rivers as is shown in our illustration.

It is claimed that this method prevents the washing out of materials and avoids the necessity of cofferdams in many cases.

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

The next Examination for Graduateship and Associate-Membership of the Concrete Institute will be held on Thursday, October 20th, and Friday, October 21st, 1921, in London and at Salford, Edinburgh and Cork. Applications for all particulars should be addressed to the Secretary, Concrete Institute, Denison House, 296, Vauxhall Bridge Road, Westminster, S.W.1.

All applications for sitting for these Examinations must be received not later than September 22nd next.

COUNCIL FOR 1921-22.

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Workman, G. C., M.S.E.
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RECENT SUCCESSES IN THE CONCRETE INSTITUTE EXAMINATIONS.

Bridges, George Percival (Part II).
Cope, George Ivan (Part II).
Edmondson, John, Stud.C.I. (Part I).
Joyce, Harold Frederick William, Stud.C.I. (Part I).
Low, Victor Thomas (Part II).
Lutkin, Frederick Edward (Part I).
Naylor, Alan (Part I).
Radnall, Herbert Thomas (Part I).
Schofield, Reginald William, Grad. C.I. (Part II).

CONCRETE AGGREGATES—*(continued)*.

Note.—The publication of these lists commenced in the August issue, 1920, and was continued in the issues for September, November, December, 1920, and in March, April, May, June, July and August of the present year.

The Concrete Institute takes no responsibility for the accuracy of the information supplied.

For footnote references, see September, 1920, issue.

(52*a*) **Kintyre (Argyllshire)** :—See also (3) August, 1920. Mr. Walter Bonn, Road Surveyor, Campbeltown, writes (17/7/19): "Aggregate for concrete in this district is mostly shore gravel, it being the most suitable local material. The rock in this part is mostly of a comparatively soft nature and not suitable for concrete work. There are no transport facilities either, and the writer hauls it from the nearest shore for concrete required for bridge construction."

(53) **County of Lancashire** :—Mr. W. Compton Hall, County Bridgemaster, writes (14/7/19): "Local stone or river gravel broken to pass through a 2 in. ring. Mixed in the proportion of 3 parts to 1 part of clean gravel, 1 part of Portland cement. The quantity available in the County is unlimited."

Mr. R. C. Branston (R.C.B.) sends the following information:—"Partington slag, containing sulphur; also Whinstone or Lancashire flagging, which proves satisfactory."

(53*a*) **West Lancashire** :—

General description : Sand and gravel.
Source and locality of same : Gorse Hall, near Chorley.
How obtained : Hand-loaded into horse-drawn carts and motor lorries.
From whom obtained : Gorse Hall Sand & Gravel Co.
Is available quantity limited ? Unlimited.
Present maximum output per day : (19/8/1919) 200 cu. yards (more if required).
Is there any provision at or near source for washing, or crushing ? Washing not required. Crushing not required : all sizes.
Price per cubic yard, and where delivered ? 12/6, on barge.
Is composition uniform ? In any particular seam, Yes.
Kind of stone or coarse material : River gravel of an ancient river-bed.
Kind of sand or fine material : River sand of an ancient river-bed.
Relative proportions of coarse and fine material : Seams, fine sand; also gravel.
Shape of particles : Angular, some round.
Approximate percentage that needs crushing to pass $\frac{3}{4}$ in. screen : 5 per cent.
Impurities present : None; occasional lumps of shale.
Source of information : Mr. L. J. Pond, late Superintendent of Works, Economic Building Corporation.
General remarks : In good demand for reinforced concrete works around Blackburn and other towns on the Leeds and Liverpool Canal.
Weight per cu. foot, dry : 1·12 cwt.
Granular analysis : Believed to be 36 per cent. Silica.
Proportion of muddy matter : 1 per cent.

LAND SUBSIDENCE AND ITS EFFECT ON CONCRETE AND OTHER STRUCTURES.

By LAWSON S. WHITE, A.M.C.I., A.M.Inst.C.E.

(*Abstract concluded.*)

From a Paper read before the Concrete Institute at the One Hundred and Fifth Ordinary General Meeting on Thursday, May 26th, 1921.

Sliding.—The resistance to movement created by friction of soils on soils or structures on soils is the fundamental cause of their stability. Many failures of embankments, retaining walls, dock walls, etc., are attributable either to a subsequent loss of frictional resistance or to the exceeding of the resistance value in design.

Water is the chief enemy and, unfortunately, it is almost impossible in many cases to avoid its penetration to foundation beds.

Good drainage is therefore essential where possible. In cases where it is not possible to avoid water penetration, foundations must be taken down far enough to ensure their stability under the worst conditions, and lateral thrusts should be relieved or balanced to reduce their effects to a minimum.

Flowing of Soil.—When its cohesive strength is exceeded a soil has a tendency to flow like a plastic mass. In some cases the breaking down of cohesion destroys a resistance that cannot be regained, and movement continues until the pressure is distributed over an area large enough to bear it. In the Culebra Cut of the Panama Canal the clay at about canal bottom was forced to flow on account of the enormous weight of earth above it, and it bulged up into the fairway.

By increasing water content beyond a certain limit we reduce the cohesive strength of soil, and adequate drainage of soils subject to saturation is therefore desirable.

Landslides.—Excavations for new buildings in districts already built upon are a constant source of danger and trouble on account of the little attention paid to earth pressures, and even when shoring is placed to counter the thrust of the earth behind, it is often inadequate or removed too soon. A slight settlement may break a sewer or water main and thus develop into a much more extensive slide.

At first sight there appear to be many varieties of landslides, but on investigation we find they are mainly attributable to the same cause, namely, water action.

In addition to lubricating a surface, water will transmit the pressure due to its head on the underside and at the back of the slide and so force it forward. The avoidance or elimination of trouble seems to be achieved by a thorough investigation of the geology of a district before construction is begun and by drainage where necessary.

Unequal or Excess Loading on Weak Soil.—So far, failures due to unforeseen or unexpected natural conditions have principally been considered. More often, however, the human element is at fault, and this is not to be wondered at when so little definite information is available for the use of designers.

For buildings on ground of low-bearing value spread footings or raft foundations are often used, in which case care must be taken to distribute the load equally, so that subsidence, if any, will take place uniformly. An unequal settlement will throw the centre of gravity of a building further towards the overloaded side, and thus cause still greater movement, which, to a structure of considerable height, might prove fatal.

Reinforcement of the "raft" is a steadily growing practice and has proved successful in many cases. The steel may be placed either in the body of the mattress, as slab reinforcement, or more efficiently, between the column bases in beams or cantilevers formed in trenches of the desired dimensions cut in the foundation bed.

In calculations to determine the bearing area for buildings, the live load must not be neglected. A convenient method of calculation is to consider that footing in which the live load bears the highest proportion to dead load, and to note the area needed to support its total load at the allowable unit-bearing value. From this, neglecting now the live load, we can calculate the dead load per unit area for the footing and adopt this as the unit for the calculation of areas required for the other footings.

Pile foundations are often abused and sometimes placed where absolutely useless.

A pile driven down to a material of good bearing capacity will sustain its load as a column, but when a suitable bed is too far distant a pile may be driven for a length into a weak soil, when it will transfer its load by skin friction. Although piles will bear a high vertical thrust, they are weak laterally, since they are easily forced through the soil and serious failures have occurred on account of lateral pressure, such as might be expected with a retaining wall. Piles should therefore be driven in the line of resultant pressure.

In soil of a compressible nature it is seldom that a building maintains its original foundation level, but such slight subsidence is not to be feared if it is uniform, and it is a growing practice to expect a small settlement and make allowance for it. An effort should, therefore, be made to tie a building well together, and make it act more as a unit than a collection of disjointed parts. Reinforced concrete is by nature an ideal structural material under such circumstances.

During the construction at North Transcona, near Winnipeg, Canada, of one of the largest railroad gravity yards in the world, many difficulties were met with because of the treacherous nature of the soil. The surface drainage—naturally very slow by reason of the flat country—was still further hindered by the intersection of many land drains by heavy gravel embankments.

Adequate culverts were of course laid through the banks, but a heavy winter's fall of snow and a sudden spring thaw flooded the country. The ground was therefore thoroughly saturated, and as the frost came out of it the loamy soil was left in a very pasty condition.

After the deposition of one of the heaviest gravel fills—about 35 ft. high—a general subsidence took place on account of the crushing of the top soil, which had not been excavated. This movement was temporarily checked by a winter's frost, but when the thaw penetrated the ground the slide recommenced and great rolls of earth were forced up at the toe of slope. This upheaval reached in places an elevation of 12 ft. to 15 ft. above ground level. A box culvert composed of 12 in. by 12 in. timbers, well drifted together, was so badly twisted that one end was forced up diagonally about 15 ft. to 18 ft. from its original position. At the highest part of the hill a bridge subway was constructed to allow the passage of rolling stock through the embankment. The gravel fill was to be held back by concrete wing walls. As the back-filling proceeded these walls began to bulge and to move forward much in the same way as the earth was forced up. Excavation for foundations in the vicinity revealed a soft layer of silt a few feet below the surface, which probably facilitated the sliding movement, but the wedging action, caused by the settlement of the great weight of gravel into the soft top soil, must have created an enormous lateral pressure, far greater than any which might have been expected from the gravel itself, had it been on a firm foundation bed. Tee-shaped excavations were made in front of the cracks in the walls, and reinforced concrete bolsters were placed in an attempt to spread the pressure behind the weak point, over a large area. These efforts proved partially successful, but sections of the wall had to be removed and rebuilt.

Owing to the approaching harvest temporary measures had to be adopted to make use of the completed storage yards, which contained many miles of track; trestles were erected to support the bridge girders, long piles were driven through the moving embankment into solid ground, and upon these a timber superstructure was built to carry the track.

These unfortunate events naturally directed attention to the stability of other buildings in the neighbourhood, and it was feared that a 200 ft. reinforced concrete chimney might fall a victim, but happily no settlement of a serious nature occurred.

Then the thunderbolt fell! As the grain from the harvest arrived it was dried and stored in the elevator, an enormous reinforced concrete structure, composed of two main parts. The front portion, 70 ft. to 96 ft. and 180 ft. high, was called the workhouse, and contained machinery for handling the grain as it came from the cars; the back part, of over-all dimensions 77 ft. to 195 ft. and 102 ft. high, was called the bin-house and consisted of 65 circular bins, arranged in five rows of thirteen, having a total capacity of 1,000,000 bushels. Great care was taken to distribute the load evenly, but when barely 875,000 bushels had been received, a sudden settlement took place, and within an hour a vertical sinking of 1 ft. had occurred. This was followed immediately by a tilt to the west, which continued, until at the end of 24 hours the building had come to rest at an angle of 26° 53′ to the vertical. The failure and righting of this elevator were made the subject of a paper,* delivered by Alexander Allaire to the American Society of Civil Engineers, from which a few references have been drawn.

The foundations of the elevator were of the " raft " type, which had been found adequate and satisfactory under practically similar conditions. The workhouse rested on a 30-inch reinforced concrete mat, about 16 ft. below ground level, on which the superstructure was carried by R.C. columns giving 500–800 tons load apiece, and totalling 14,400 tons. The bin walls were of 6 in. reinforced concrete and rested on a 12 in. R.C. slab, which formed the bin bottoms. Below this slab there were four conveyor belt tunnels 7 ft. square, formed by walls 16 inches thick, resting on a 2 ft. R.C. raft at 12 ft. below ground level. The tunnel walls were not bonded, except by cement adhesion, either to the mat or R.C. bin slabs.

The geological formation of the district is of a uniform nature. First comes 2 ft. of heavy black loam, then reddish-grey clay 5 ft. or 6 ft. thick, generally water-bearing, which changes gradually to blue clay extending to approximately 40 ft. below the surface. Here it changes suddenly to white clay, interspersed with limestone boulders. Under the white clay a stratum of shattered limestone about 30 in. thick overlies the limestone rock, which at Transcona is from 53 ft. to 55 ft. below prairie level.

Small area tests indicated that the blue clay would support a load of 4 tons per sq. foot. The designed full load of the bin-house was 3·3 tons per sq. foot, distributing a load of about 50,000 tons over the whole area. The empty structure weighed about 20,000 tons.

After the failure, a series of borings revealed an unusual ridge of boulders, 12 ft. higher than the rock, along one half of the east side of the bin-house. This undoubtedly caused the tilting towards the west, since during the vertical settlement the clay at this point would be compacted between the boulders and the foundation. The white clay was soft and profusely water-bearing, and the ground water level was at approximately 26 ft. below the surface. This indicated a head of 14 ft. at the base of the blue clay. The depth of clay beneath the foundation was 28 ft.

The question arises :—What caused the initial vertical settlement ? Various suggestions have been made, including that by Mr. Allaire, who attributed the subsidence to " the flow of clay under the heavy load." The author of this paper ventures to suggest that the failure can perhaps be accounted for as follows (he does not pretend to have dealt accurately with the figures, but only to have used rough calculations to make his argument clear).

The thickness of the clay below the mat was 22 ft. and (supposing the load to be distributed uniformly through an angle of 45°) this would give a bearing area at the base of the clay of approximately 29,000 sq. ft. Against this reacted a pressure head of 14 ft. of water, which will support a load of approximately 900 lb. per sq. ft. or a total of 13,000 tons. The load at failure was 46,000 tons. This leaves 33,000 tons to be supported by the slab of clay and the resistance offered by the water to being driven out of the white clay. Assuming ¾ ton as the tensile strength of blue clay, and the area of distribution as that formed by planes through the clay at 45° to mattress edges, we obtain a supporting value of approximately 14,700 tons. There are thus left 18,300 tons to be supported by the resistance of the soft white clay to flow or to the displacement of its water content. Figures for the bearing capacity of the white clay under head of water are not available, but it is thought very possible that they would be found considerably below the required value.

A similar instance is quoted by Mr. W. R. Phillips,† M.Am.Soc.C.E., in which piles were driven to a dense stratum about 65 ft. below the surface, but failed on account of a soft water-bearing stratum below, out of which the water was gradually forced.

The elevator having tilted continued to sink until it was held back by a cushion of earth that had been forced up on the west side. Excavation under the low edge showed the white clay to have been squeezed dry, and to be so hard that it had to be picked out. In some cases the blue clay was driven down into it. This seems to justify the suggestion that the settlement was due to the water being squeezed out of the white clay.

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* Am. Soc. of Civil Engineers. *Transactions*, Vol. lxxx. (1916).
Discussion on Mr. Allaire's Paper.

The splendid behaviour of the reinforced concrete was quite a feature of this remarkable accident. An inspection by the author revealed very few cracks, and these were almost unnoticeable. During subsidence and righting the unbonded tunnel wall remained intact.

Conclusion.—By this short summary of the various causes of subsidence and by passing references to a few actual failures, the author hopes that attention will be directed to the need for a closer study of this subject, and that from this a more confident practice will result.

DISCUSSION.

The President opened the discussion with a reference to one or two cases of subsidence that had come under his notice, which he illustrated by means of sketches on the blackboard. In the first case, a building had been supported by means of a raking shore, and at the foot there was a solepiece, and it was found that there was a land drain pipe within four inches of the solepiece. In another case, in a coal-mining area, the settlement of the ground had caused a cast iron column to give way. This was in a railway station platform, in which there was a series of girders carried by stanchions. It so happened that there was an incipient crack in the column which was not noticed until the bottom half of it sank away from the upper half. In another case, which was duplicated in different districts, the front wall of a house came down to a lower level at the front bays. In both cases the footings of the bay windows were above the fosse line, and the soil was clay, which had more or less walked about. In the dry weather it had cracked, and in the wet weather it had swollen, and in one case one wall had actually travelled forward about two inches from the other wall. In the other case it had settled down. The defects were remedied in one case by rebuilding, and in the other case concrete was put in as a support. In another case, on the sea coast, the sea had undercut a chalk cliff, on the top of which was a building. The chalk slid down and the house sheared in half, the front half falling away and the remaining half standing. Again, in the salt district in the north, owing to the salt working the ground subsided and caused big cracks in a wall with an opening in it, and the archway of the opening fell away. Drainage was the cause of another difficulty. It was complained that a house was damp, and it was found that land drains had been put down to drain the land at the back, and the consequence was that the whole ground settled down, the foundations came away from the upper part of the wall, and the water poured in.

Mr. F. G. Keene referred to his experience with factory buildings in London. The buildings were in the neighbourhood of docks, and consisted of a group of thirty, having a total floor area of 292,000 sq. ft., some being one-storey and others multi-storey structures, the highest having five floors. The majority of these buildings were substantially built with brick walls, steel or cast iron columns, and floors of special fire-tile carried on steel girders, the greater number having flat roofs, but unfortunately, while the more recently constructed units had piled foundations, many of the old structures were carried on ordinary concrete footings placed at the usual depth and laid directly on the soil. The present age of the buildings varied from eighteen to seven years, and they had shown no unusual signs of subsidence until 1913, at which time rapid movements began to take place. The movements were not confined to these buildings, for practically all the buildings in the district for a considerable distance were affected in the same way. Just about this time excavating work had been commenced in connection with the construction of a new dock, and it was thought that, due to the pumping operations connected with the drainage of the dock workings, the subsoil water was being withdrawn, resulting in the disturbance of the subsoil itself. It was, therefore, decided to investigate the level of the water in the subsoil, and for this purpose a boring was made 16 ft. deep in a convenient position at a point nearest the dock workings, and readings of water level were taken every three days. The figures obtained by these measurements, however, appeared to be rather erratic, and in 1914 it was decided to make two deeper borings in two other parts as a check on the first one. It was found that the difference in the average subsoil water level during the dock construction, compared with the level after the completion of the dock, was 6 ft. In February, 1916, a test was carried out extending over 32 hours, to ascertain the influence of the river tide on the subsoil water level. At low tide the river water level was 8 ft. below, and at high tide 13 ft. 7 in. above that of the average water level in the subsoil, and it was noted that for a variation of 21 ft. 7 in. in the height of the river water the maximum variation in the subsoil water level was only 1·2 in., and that the latter lagged three hours behind the river. During 1913 and the early months of 1914 the movement in the buildings was comparatively fast, until it seemed that a new position of equilibrium had been reached, which, although arresting the rapid movements, put abnormal stresses on all parts of the buildings. Then followed a period in which, under the influence of these stresses, distinct breaks occurred between adjacent buildings, and the component parts of others moved relative to one another, shearing the fixing bolts and rivets of the steel framework. In a general way movements then continued more slowly, although certain buildings moved very much faster than others, until the dock was filled in 1920, when the settlements became comparatively negligible.

Mr. H. J. Deane, M.C.I., M.Inst.C.E., said that some years ago a river pier had to be constructed at Strood, near Rochester, and the foundations were bad. The soil was a blue alluvium, commonly called bungum, and the foundations were not carried down to the best possible depth, but rather spread out in such a way that the load was as nearly uniform over the whole foundation as possible. Shortly after the abutment was built it was reported first as having sunk 1½ in. and later to have risen ⅛ in. above the original level. A close observation was kept and it was found that the actual cause of the movement was found to be a bad bit some considerable number of feet below, which had come out of the river, and this was expanding and contracting, which made the abutment go up and down. The abutment was still there, and still going up and down. Another rather interesting experience connected with foundations was when the Central London Railway were extending the tube to Liverpool Street Station. At Liverpool Street Station there were some large columns carrying the main roof. These columns took a load of some 50 or 60 tons, and it was the speaker's duty to have to under-pin one of these columns in order to construct a subway in the immediate vicinity. A hole was sunk down to the level of the foundations, and it was found that the columns were on very fine sand, which was perfectly dry, and ran just as would the sand in an hour glass, so that they could not possibly under-pin it in the usual way. They had to find another method of securing the column, which held up, not only 50 tons, but practically the whole roof, and if anything happened the roof would come down on to the main lines and booking offices. The final arrangements made were to drive steel sheet piling round the column foundations down into the clay, and so confine the sand. That having been done, they proceeded to excavate, and there was not the slightest movement of the column. He wished to utter a word of warning in connection with subsidences. In connection with the same railway many years ago, just after the line was opened, they built a generating station at Shepherd's Bush, composed of two main buildings, generator house and boiler house. The boiler house was originally fitted with a number of Babcock and Willcox boilers on each side, with space for two more on each side. Everything went well until it was found that the traffic warranted the installation of more boilers, and for some reason it was decided to put in a different class of boiler. Shortly after the work had been finished he was instructed to report on some apparent subsidences at the corner of the building. It seemed that the corners had given way, and they contemplated under-pinning, but before deciding it was necessary to take some very careful measurements as to what extent the corner had gone down, the result of which showed that the corner had not gone down at all. In fact, what had happened was that when the new Cornish boilers were put in they continued the old type of construction at the back for the flues, and the flue gases from the Cornish boilers being of a very much higher temperature than from the Babcock and Willcox boilers, the panel immediately behind the boilers had expanded both sideways and upwards and upset the equilibrium of the wall. That was an interesting thing which very few people came across, and was a warning not to jump to the conclusion, because there was a crack in a wall, that the foundations had gone. He thought one of the most important things one had to consider when dealing with foundations was the question of confining the ground if dealing with poor materials, so as to be able to get the pressures on the soil

Dr. J. S. Owens, F.G.S., etc., referred to the large number of accidents which occurred due to settlement. That meant that there was something unknown, something they were not able to cope with yet, because they did not understand what was the cause of the settlement. Mr. White, in his paper, had made a calculation for bearing power in which he had included a head of water in the subsoil as a support, and Mr. Keene had shown slides illustrating settlements which he attributed to the removal of water from the subsoil. In the one case settlement was attributed to the removal of water and in the other case the water was assumed to be a support. The effect of water in the subsoil, or in any soil, varied. If they took a very fine clay which powdered, or very fine sand in the dry state, it had little supporting power, whereas if a little water were added, just sufficient to moisten it, it acquired some supporting power. He suggested that it was entirely a sub-stratum phenomenon. So long as there was sufficient water to separate the grains and air spaces were avoided, adhesion was increased. If they increased the water so that there was air space it began to flow, and if they went on sufficiently to make a mud, it lost all its supporting power. He had observed a good deal of instances of settlement on the sea coast, and called to mind several houses split in two in the way the President had pointed out, and one of the effects of water was very prominently brought out. 'When cracks appeared in the soil above the face of the cliff, and wet weather followed, it was almost sure to produce landslides. The supporting power of quicksand had been referred to. There was a peculiar thing in connection with sand when in suspension in water which perhaps was not generally known, and that was, if they took the specific gravity, the supporting power in that sense, by putting a hydrometer into a mixture of sand and water it would register the same specific gravity as if the sand was in solution. The difference was exactly proportionate to the amount of sand, and its specific gravity also.

Mr. Henry S. Jardine, M.C.I., noted that in the early part of the paper there was something which he considered to be a very important point. The author had said, "A soil which has cohesive properties will naturally derive support from the earth in contact with its lateral surfaces. As the area increases the lateral surfaces become relatively smaller in proportion to the area, and consequently a larger unit load can be supported over a smaller area than over a larger one." Later on he said, "Small area tests indicated that the blue clay would support a load of 4 tons per square foot. The designed full load of the bin-house was 3·3 tons per square foot, distributing a load of about 50,000 tons over the whole area"; so that small test areas were made indicating that the blue clay would take 4 tons per square foot, and the design was made to allow 3·3 tons per square foot. The bin-house really failed at 3 tons, i.e., before the bins were actually full, so that he thought the engineers who designed it were misled by these small area tests, and loaded the clay more than it would bear. The clay would appear to be something like the ordinary clay which was referred to as being able to support 2 tons per square foot, according to the L.C.C. (General Powers) Act, 1909, so that if the engineers had spread their foundations about 10 ft. round on each side there would have been no difficulty. Another point was the question of unequal loading, and a point arising out of that was the unequal resistance of ground to loading. They might have rock with pockets of softer material between it, and if unequally loaded there would be an equal distribution over the whole. As to the grain silo, apparently there was a big lump of limestone rock in the clay. When the subsidence occurred, this rock prevented the clay subsiding, and the thing tilted over.

THE DECORATIVE TREATMENT OF REINFORCED CONCRETE.

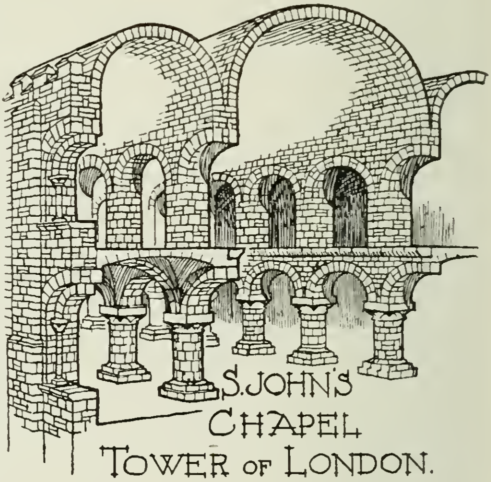
By E. GODFREY PAGE, A.R.I.B.A.

THE life-history of every new discovery in the methods of constructing buildings for the habitation or the use of man shows two phases: the first purely utilitarian, the second highly decorative. It is true that no exact line can be drawn between these, and there is always a period in time when the first is seen to have gradually merged into the second; but it is none the less true that in all the great periods of building effort—what are commonly termed the great architectural "styles"—we can observe that during its early years the designers in the new style were concerned purely with the utilitarian problems of construction, evolved through a long course of experiment and often of failure and even disaster, and that they had neither the faculty nor the inclination for even the most elemental decoration of their material.

We see also, however, that, as experience brought certainty of structural success and its consequent confidence, the instinct inherent in man compelling him universally under whatever conditions to express the interest and pleasure he had in making a thing, and to express it on the thing itself, that instinct showed itself at first tentatively, even childishly in pattern and ornament, but, as confidence grew, surely and powerfully in moulding, proportion and fine finish and ended almost universally in the exuberance and unsuitability of ornament obscuring the character of the material employed.

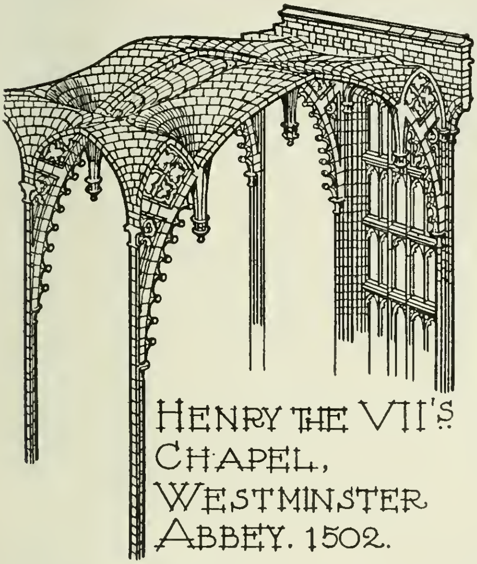
For Englishmen—even Londoners—in the architecture of the Middle Ages, this course from the purest utilitarian building to the most opulent splendour of decoration can be observed with ease, and, as it focuses and epitomises a like course in all the great building movements of the past, it is worth while to spend a moment in considering it, and in deriving from it, if we can, any guidance for ourselves, faced, as seems certain, with what the historian will regard as the mark of a new epoch, the Concrete Age.

Let any reader then, who can spare the time, visit the Tower of London and see the chapel of Saint John. Its date is 1080, and it is one of the few surviving examples of the earliest buildings of the Mediæval style. Now that style was not deliberately selected from half a dozen others as the architect selects a style to-day. It was the superseding of the only devices for building then known by a more scientific form which knew it could do bigger things, and was, when you analyse it, a system of using the comparatively small stones which were all that could be got to span large openings: it was a discovery or invention in the sense that ferro-concrete is to-day. With such materials, the beam of any length being impossible, the arch developed as the chief feature, and all the effort of the designers was concentrated on no more than structural achievement. They were satisfied to make their building stand up and be covered in, and many a failure with loss of life occurred in that primitive school



of building. Here you may see pure, unaffected engineering, clumsy, bald and unattractive, with no hostages to artistic sentiment, but the best its authors' knowledge could produce and a scientific miracle to their contemporaries.

Now skip four hundred years and visit the chapel of Henry VII, Westminster Abbey. It is also built of small stones ; it has also its chief structural feature in the arch, now become pointed ; but it is such a blaze of technical dexterity, of ornament used for its own sake, that as a piece of constructional truthfulness it is inferior to its forbear at the Tower. Between the two, however, is a long path of tentative effort, the early moulding and patterning of the stones quite baby-like in its experimentalism, and somewhere—the critics still argue as to just where it lies—there is a point where the supreme expression of the engineer matches the accomplishment of the artist, and this marks the zenith of the Gothic style.



HENRY THE VII'S CHAPEL, WESTMINSTER ABBEY. 1502.

The same path, from the frankest statement of a constructional problem solved, through years of expressing this as a gradually perfected æsthetic effort, to the climax when some new discovery in construction took its place, can be traced in all the great building phases of the world's history. What lesson does it teach ; what guidance does it offer us for the future of Reinforced Concrete ?

It is the object of these brief articles to offer some suggestions, not dogmatically, but in good faith, not shackled by the glamour of the past, but confident in the belief that in sincerity to the technique of the material is the great and indeed the only hope of success.

For it is to be noted that all through the period which has just been dwelt upon, the builders relied purely on expressing the nature of the material—stone—in which he built. He never pretended that it was anything else, while it could be shown that some of the other great movements in the history of building failed, and impress us little to-day because they did not keep this sincerity before them.

And we should be lacking in this sincerity did we not recognise at the outset that there is one great outstanding difference between the conditions in which Reinforced Concrete finds itself, and that of all the previous building movements of the world. It is this : That, while with them, without exception, the engineer and the artist were combined in one man, it would seem by the very essence of the case to be absolutely impossible to have this to-day. It is clear to precision, not only that the minds of those who constructed the vast cathedrals of the Middle Ages dictated and designed, and that their hands often actually executed the ornament and decoration, but also that in quite other times, such men as Michael Angelo and our own Sir Christopher Wren worked out the stresses in the domes respectively of St. Peter's, Rome, and St. Paul's, and were intellectually responsible for their stability. Now Michael Angelo was a painter and sculptor of the first rank, and though Wren was neither, it is certain that he was an artist in a sense which no engineer to-day would claim to be.

Now the great outstanding accomplishment of the nineteenth century, the one which embraces all others, was the discovery of the value of specialisation of effort, and when the immense potentialities of the scientific treatment of building materials began to be realised—accompanied as a historic fact by the great increase in the output of iron and later of steel—it soon became inevitable that in the design of buildings two divergent paths should be taken by those engaged in it ; the scientist separated himself from the artist—in a word, he became the engineer—and, though there was a short period about 100 years ago when Rennie and the race of engineer-architects erected both bridges and buildings, the engineer tended more and more to neglect the art of architecture and to become a pure scientist, while the artist among architects drifted so far from the modern science of construction that to-day, except for small buildings, he can scarcely be said to be a constructor at all.

A great deal of effort, much rhetoric and much ink have been spent in deploring this. If there be anything certain to-day, it is the absolute futility of doing so any longer. If there be one thing clearer than the fact that architectural designing is a matter of a life's concentrated training and ceaseless study, it is that acquirement of the theoretical scientific knowledge of the strength and behaviour of precious materials under stress leaves no time for the study of æsthetic laws. If either the engineer or the architect spent a fifth of the time needed to acquire any knowledge of the others' medium worth having, he would inevitably injure his effort in his own specialised métier. The proverb "*Ars longa, vita brevis est*" might now be rewritten "*Ars et scientia longae sunt*," while *vita* is just as brief as it was when Wren designed both the structure and the classic orders of his great dome. In brief, there is not time in a life for one man to be an engineer and an artist as well, besides which the very faculties which dictate an artistic career for a youth, usually render any but the most superficial science repulsive to him, and the same is true inversely of the leanings which make a young man an engineer. To any artist who doubts this may be commended an hour with a textbook on shear bars, or the modulus of elasticity, while the B.Sc. who thinks he has time to be an artist too, except as a hobby, may convince himself that he is wrong by a glance at history of mediæval mouldings, or the speculations on the ocular refinements of the Parthenon.

Perceiving, therefore, the folly of pretending that these two men with their separate outlooks can be amalgamated into one, as they were up to the death of Rennie, the best hope for a constructive policy for the future of concrete seems clearly to lie in a partnership of effort.

For it seems certain that without such unity ferro-concrete design will drift in two directions equally bad. It will either be handled purely by the engineer with that contemptuous indifference for art which has done so much to disfigure the world for near a century, applying to it occasionally, what is perhaps worse in the eyes of the man of taste, the engineer's " ornament," such as makes Blackfriars and Charing Cross railway bridges an outrage ; or, if it be demanded that what are called the " amenities " should be observed, an architect is brought in to decorate the structure. He usually hates the sight and name of Reinforced Concrete, and is vaguely jealous of the superior constructional knowledge of the engineer. He opens, therefore, his carpet bag of architectural features and covers the whole thing up with brick and stone columns, cornices and pediments all borrowed from the past, and all having no relationship at all to the actual building. He has by no means decorated the Reinforced Concrete, he has simply smothered it, and while his feeling for the engineer is little less than hatred, the engineer's for him is no more than contempt.

This way lies intellectual bankruptcy, and while the treatment as distinct from the hiding of ferro-concrete is ignored, as it has been almost entirely by the one man competent to make it comely, the trained architectural designer, its future is likely to be one of marvellous scientific accomplishment, but such that all those who love a beautiful country-side and beautiful cities will regard with dread.

(*To be continued.*)

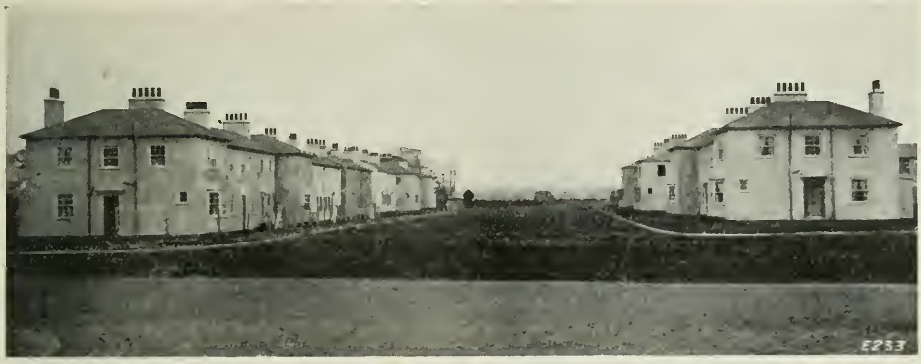


Fig. 1. The first fourteen houses to be occupied.
MARTON GROVE GARDEN SUBURB, MIDDLESBROUGH.

CONCRETE COTTAGE BUILDING.

MARTON GROVE GARDEN SUBURB, MIDDLESBROUGH.

THE Marton Grove Garden Suburb is one of the schemes undertaken by the Middlesbrough Corporation under the 1919 Housing Act. It comprises 900 houses. Out of this number 418 are to be erected of concrete on the Dorman Long system, known as " Dorlonco," and consisting of a steel frame with Hy-Rib metal lathing, iron encased in concrete.

Owing to various unavoidable delays it was not possible to start the work until June, 1920, the erection of a steelwork for the first block being begun on June 27. But the work did not proceed as rapidly as might normally be expected owing to the shortage—which was felt everywhere—of plasterers. Although it is possible to make use of unskilled labour on these houses (provided there is skilled supervision) to a much larger extent than is possible with brick houses, nevertheless the plasterers' work is an important item. Now, however, good progress is being made and houses are being completed at the rate of six per week.

The site is an extremely pleasant and healthy one, being on high ground with pleasant contours, of which full advantage has been taken in laying out the scheme by the Borough Engineer, Mr. S. E. Burgess, M.Inst.C.E., whose endeavour has been to obtain as great a variety of aspect as possible. Variety is also obtained by grouping, by the addition of bay windows and by the treatment of the door hoods and such-like details. A slight change in the usual method of construction adopted with this system has been made with the roofs, which are covered with slates on boards instead of concrete, otherwise the methods employed are similar to those previously described in this journal in connection with Dormanstown.

An interesting feature of this work was its organization. *Fig.* 3 shows the central depot that has been formed in connection with the plastering work. Here the materials are stored until required for use, and then they are machine-mixed ready for application in a large concrete mixer and mortar mill driven by electricity. The concrete for the foundations is also machine-mixed, small petrol-driven mixers on bogies being used and run to follow the work as it progresses. Furthermore, there is a most complete arrangement of narrow-gauge track for the economical and rapid handling of materials. The internal walling slabs are also manufactured at the central depot: by this means it is possible to

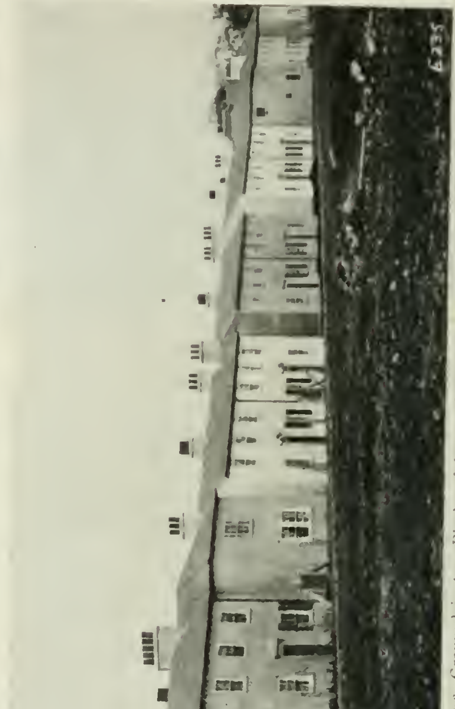


Fig. 2. A Row of Fourteen Houses, Grouped in two Blocks of four and three Blocks of two. Marton Grove Garden Suburb, Middlesbrough.

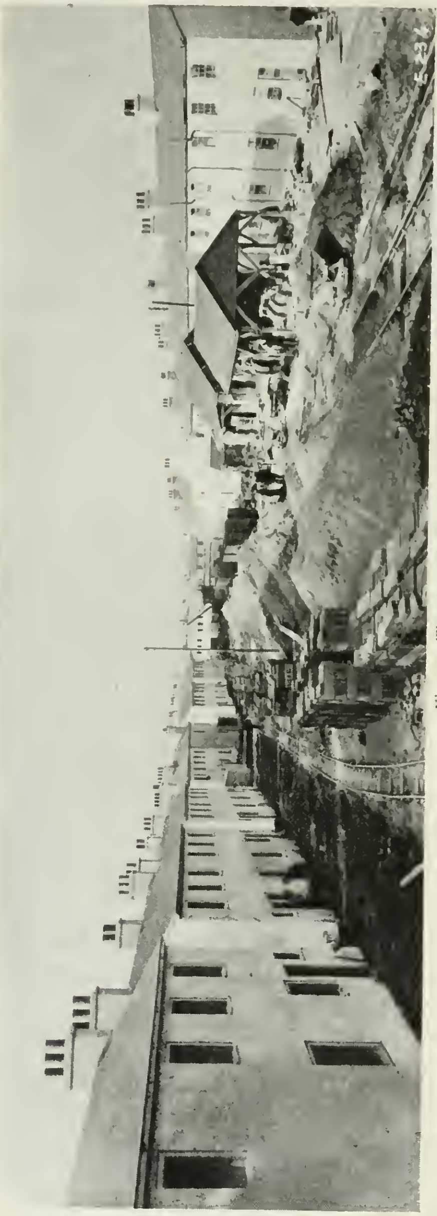


Fig. 3. The Central Depôt.

exercise very thorough supervision over the work, which is so essential in schemes of this kind where improper workmanship inevitably ends in disastrous results.

The Cleveland district, in which these houses are built, is extremely exposed, but the type of wall used, viz.: a tough outer skin of concrete applied to Hy-Rib reinforcement, a 4½ inch cavity and an inner skin of coke-breeze concrete slabs has withstood the roughest weather.

By June this year about eighty houses were finished, of which sixty were actually occupied. *Fig.* 1 shows the first fourteen houses to be occupied. At the same date about 270 foundations were completed and the frames erected ready for the application of the expanded metal reinforcement for 220 and the internal plastering of about 110 houses was finished.

Fig. 2 shows a row of fourteen houses symmetrically grouped in two blocks of four and three blocks of two. Those who are accustomed to irregularities of outline and who think that the quantity of intricate detail is the measure of good architecture, or who confuse picturesqueness with design, may find the houses dull. Yet they possess all the characteristics of those placid façades that adorn the high street of almost every small country town in England. The observant traveller cannot fail to notice the air of peace and homeliness which such houses emanate, for they are indigenous to English soil and expressive of the national temperament. The only difference between those houses and these, their modern counterpart, is that the former have had time to settle into their surroundings with which they harmonize and thus acquire an air of perpetuity. But such considerations, delightful as they are, must not be allowed to distort architectural criticism, and it is safe to predict that in the course of time these too, as their walls and roofs become mellowed, with here and there a creeper over their surfaces, as trees and shrubs grow in their gardens, as the roads and hedges become a little worn with traffic, will assume that same venerable and delectable charm that now exudes from their earlier prototypes.

MEMORANDA.

The Housing Problem and Local Byelaws.—In a circular issued by the Ministry of Health it is stated that:—One of the difficulties which besets builders of to-day, proposing to build houses, is the existence of byelaws which were framed at a time when the inherent difficulties of building were far less acute, byelaws which do not take into account the progress which has been made in the development of new methods of construction. Complaints have been made that some of the requirements of these byelaws are antiquated and inappropriate to modern conditions.

This was foreseen at the time of the passing of the Housing Act of 1919 and provision was made to enable local authorities in the carrying out of housing schemes to depart from their byelaws and to permit the same latitude to other developers. Further the Ministry of Health were empowered to make Regulations overriding local byelaws and these were framed on a broad and generous basis, limiting the restrictions to the minimum compatible with due regard to life and health.

Moreover a right of appeal is given to the builders in the event of the local authority proving unwilling fully to avail themselves of the wider powers. It is significant, however, that there have only been fifty-five such appeals, which clearly proves that most municipalities are willing enough to grant the much desired relief to builders in their districts.

Crossens Concrete Houses.—The Ministry of Health have fixed the selling price for the Southport Corporation concrete houses at Crossens as follows: Living room and three bedrooms, £580; living room and four bedrooms, £610; parlour type, three bedrooms, £650; flatted type, living room and two bedrooms, £500.

CIVIL ENGINEERING CONFERENCE.

A NUMBER of subjects of interest were discussed at the Engineering Conference, 1921, held by the Institution of Civil Engineers in London in June last. The following are abstracts of those relating to the application of concrete and reinforced concrete :—

REINFORCED CONCRETE ON RAILWAYS.

In a paper on "The Use of Reinforced Concrete on Railways," Mr. W. W. GRIERSON, C.B.E. (Chief Engineer, Great Western Railway), after stating that reinforced concrete was used to a considerably less extent for railway work in this country than abroad, recapitulated the various purposes for which it could be adapted, such as piling, bridges, buildings, fence and other posts, sleepers, telegraph poles, name boards for stations, gates, troughs, inspection-chamber covers, paving, steps, pipes, etc. Reinforced concrete piles, he said, were capable of sustaining a considerably greater weight than timber piles of equal dimensions, and were not likely to deteriorate through oxidation of the steel reinforcement ; also they had greater power to resist the stresses caused by the operation of driving than wooden piles, and were immune from attack by the teredo worm, which caused the destruction of almost every class of timber. Deterioration of the concrete sometimes occurred between high and low water-mark and some feet above owing to the penetration of salt water and air, but if sufficient cover were allowed and the concrete sufficiently rich and properly mixed so that all the voids were filled deterioration from that cause should not occur. The use of reinforced concrete posts was rapidly increasing, and resulted in considerable saving in maintenance costs ; there was also probably a considerable future for reinforced concrete sign posts.

In the discussion on this paper, Mr. W. MARRIOTT mentioned that a reinforced concrete bridge built over forty years ago was still in good condition, although it contained bad work. In order to answer criticism, he had opened up sections of bridges built of reinforced concrete during the past forty years and had found that the reinforcement was quite free from rust. Reinforced concrete often failed, as was to be expected, because it was used for unsuitable purposes.

Mr. B. L. HURST expressed the opinion that railway engineers were too conservative in the use of concrete. A given load could be carried much more cheaply on reinforced concrete piles than on timber piles, and for retaining walls it also had great advantages. It was essential to provide full adhesion lengths for all reinforcing rods, and if that were done with end hooking and ample hooping there need be no fear of disintegration. He did not think much economy could be effected with reinforced concrete girder bridges unless the girders were placed under the slabs. The time taken to place the reinforcement and the time necessary for the concrete to set were drawbacks to this type of construction, but might be overcome by the use of pre-cast members.

Mr. H. H. ALLOTT said a reinforced concrete bridge with a 30-ft. span had been built by the Manchester Ship Canal, which weighed over 50 tons and was built alongside the railway line and lifted into place, the time occupied in the operation of placing being twenty-four hours. His experience in the use of reinforced concrete for viaducts at collieries had demonstrated that the material satisfactorily withstood shock.

Mr. W. WILLOX (late Chief Engineer, Metropolitan Railway) said he had effected a saving in cost of about one-fifth by using reinforced concrete for King's Cross bridge, which consisted of two spans over the platforms and railway of 50 ft. and 27 ft. A reinforced concrete bridge with a span of 40 ft. at Harrow had also given satisfactory results. He had also used it to a considerable extent for building construction, including offices at Baker Street and workshops, where its adoption had resulted in the charges for upkeep being practically nil.

Mr. E. H. MORRIS said he had built a reinforced concrete mound wall of pier and panel construction at a present cost of about £4 per yard, which was practically the pre-war cost of a brick mound wall.

Mr. H. JACKSON referred to the necessity for careful supervision in mixing concrete, and expressed the opinion that if the aggregate were scrupulously clean the strength of the resultant concrete would be increased many times.

Opinions having been expressed that high temperatures affected the soundness of reinforced concrete, Mr. R. P. Mears said that difficulty could be got over by adequate watering, and the failures were due to lack of precaution. Two or three inches of water should be kept on slab work for at least a fortnight after it was placed by means of a bund, and should be frequently watered after that. Timber plugs should not be inserted unless precautions against expansion and contraction were taken by wiring them or enclosing them in an iron pipe. Where the speed of the traffic was low reinforced concrete sleepers were successful and economical owing to their long life.

THE FRANÇOIS CEMENTATION PROCESS.

Mr. H. S. Ball, O.B.E., in a paper on this subject, after outlining the development of the use of cementation during the past few years, and its increasing use in filling fissures, said with the exception of red sandstone most types of ground could be efficiently dealt with by the cementation process. It had been found, however, that red sandstone could also be efficiently dealt with if the ground were first treated with injections of aluminium sulphate and sodium silicate ; these chemicals resulted in precipitate of aluminium forming in the ground, which acted as both a lubricating agent to the cement forcing its way through the pores and fissures of the sandstone and as a cementing agent itself. The introduction of these chemicals formed the basis of the silicatisation and cementation process at present being used with great success in sinkings in Yorkshire. Collieries in this country where the cementation process had been adopted had been rendered practically immune from risks of flooding. An interesting adaptation of the process had been made at the Lens collieries, where the mines were flooded by the Germans during the war by blowing gaps in the wooden tubbing below the permanent chalk water level. To deal with this situation, holes were bored around the shaft to a depth below the watery strata and cement injected at various depths, with the result that the fissures were entirely cut off, thus rendering possible the de-watering of the mines and the repairing of the tubbing by ordinary means. The introduction of high-pressure cementation pumps had considerably increased the field of cement grouting, which had been in vogue for a number of years. Not only had cracks in walls been treated, foundations consolidated, and reservoir leakages sealed, but the bed of a dam had been effectively treated, rendering a large amount of excavation unnecessary. The cementation process had also been used for solidifying and rendering impervious the substrata of the foundations to support the retaining wall of a dam.

REINFORCED CONCRETE IN HARBOURS, DOCKS, ETC.

Protecting Reinforced Concrete from Marine Deterioration.

Mr. F. E. Wentworth-Sheilds, O.B.E., in the course of a paper entitled "The Best Way of Protecting Reinforced Concrete from Marine Deterioration," said the failures in maritime structures had mainly been of four kinds.

(1) The concrete had become softened owing to the chemical action of sea-water on the Portland cement.

(2) The concrete had scaled off owing to the action of frost.

(3) The concrete had worn off owing to attrition by travelling shingle and stones.

(4) The concrete had split and cracked owing to the rusting of the enclosed steel and its consequent increase in volume.

The fourth was the most common type of failure. Generally it would be found that cement concrete of good quality could be safely used in salt water provided it was made highly impermeable. To prevent scaling in frosty weather the concrete should be allowed to harden before being exposed to tidal action, and it should also be strong and impermeable. Where concrete was likely to be worn away by moving stones it had been found advisable to use a tough aggregate with large stones, to make the concrete strong, and to let it harden in air before being exposed in position. To prevent the reinforcing steel in concrete structures exposed to sea-water from rusting probably the best method was to coat the rods with a neat Portland cement grout, as that did not decrease the bond strength, but it was liable to come off unless the rods were carefully handled. It was important to avoid overcrowding of the steel, and the use of flat steel stirrups or links, which caused voids in the concrete, and which prevented it from properly surrounding the main bars, should be forbidden. The size of the stones used in the concrete should be limited to about ¾ in., and there was now a tendency to increase the thickness of the concrete cover to 2 and 2½ in. Working stresses should be kept low, and the structure as a whole should be kept stiff, especially where heavy live loads had to be supported ; also care should be taken to prevent electric currents from passing through the structure. But probably the most effective way of preventing all kinds of deterioration was to make the concrete highly impermeable. It should be well mixed, and the stones and sand well graded. The proportion of water used in mixing should be neither too great nor too small. Probably the best void filler was Portland cement itself, and for maritime structures a rich mixture should be used. A mixture of 1 : 1 : 2 had been suggested, and although it might seem extravagant the cost of the extra cement was but a small proportion of the total cost, and the money would be well spent. It had also been found that fuel oil, paraffin wax, bituminous paint, tar, and various kinds of linseed-oil paint were more or less effective in preventing water entering the pores in concrete when applied as a coating. A simple test for permeability was badly needed, and further experiments were needed to determine the most simple and reliable test and a standard of excellence needed to be laid down.

Deterioration above Mean Tide Level.

Mr. LEOPOLD H. SAVILE, in a paper entitled "Reasons for the Deterioration of Reinforced Concrete Structures Above Mean Tide Level," said the first indication of such trouble was usually shown by a line of rust coloration on the surface running parallel and from 1 to 2 inches from the corners, the line gradually developing into cracks which enlarged until a corner came away, leaving the main reinforcement bar exposed. That also happened to deck beams well above water level. The conditions necessary for the formation of rust were a supply of oxygen and water, and especially water in the form of vapour, and on that basis he put forward the following theories as to the cause.

(1) At a certain level below high water the concrete would be continuously saturated with water, and any small volume of oxygen dissolved in it, when consumed by oxidation, would be difficult to replace. Moreover, the water would probably become slightly alkaline, and that would account for the non-appearance of rust below the line of saturation.

(2) Above the line of saturation there would generally be a certain amount of moisture in the pores of the concrete, partly in the form of liquid and partly in the form of vapour, and as the temperature rose the liquid would tend to vaporise. When the temperature fell at night some of the vapour would condense, and a supply of oxygen would be drawn in to form rust.

(3) A theory which would account for rusting at high water level might be constructed as follows : Steel was a good conductor and concrete a poor one, and thus the temperature of the steel reinforcement near the water line would correspond with the temperature of the sea (the heat being conducted upwards from below water level) and the temperature of the concrete above high-water level would correspond with the atmospheric temperature. When the temperature of the air fell at night the outer skin of the concrete would contract, but the temperature of the steel for some distance above high-water level would remain at or near the temperature of the sea.

(4) When a load passed over a reinforced concrete beam the steel would take the greater part of the tension and as it was extended its cross section would diminish, tending to produce a vacuum which would draw in air.

Reinforced Concrete for Wharves and Breakwaters.

In this paper, after mentioning some examples of reinforced concrete applied to dock construction during the past twenty years, Mr. GERALD FITZGIBBON suggested that the subject for discussion might be the caisson method of construction for deep-water wharves and breakwaters. That method, he said, had been successfully adopted in Denmark, and at Jutland reinforced concrete caissons 32 ft. long by 17 ft. wide by 26¼ ft. deep had been built on land, launched into the water, and towed to their positions and sunk in the line of the wharf of which they formed part. At Copenhagen the walls of the recently completed Kronelöbs Basin were built in the same manner, the caissons each measuring about 160 ft. long by 16½ ft. wide and 32 ft. deep. Works were at present being carried out at Valparaiso in which the submerged portion of a breakwater was formed of reinforced concrete caissons 65 ft. by 50 ft. by 49 ft. deep, which were built in a temporary dock and floated into position, where they were filled with concrete from barges. These caissons, when floated out, weighed about 2,430 tons each. The new lock to be constructed on the Amsterdam Ship Canal was to be 1,110 ft. long and 165 ft. wide with 49½ ft. over the sill, and it was proposed to build the lock head, gate recesses, and gates in a shallow excavation and afterwards tow them into position. The lock walls were to be constructed as reinforced concrete caissons and floated into position.

These three papers were discussed together.

Mr. C. S. Meik said he thought square piles should be avoided between wind and water, although the bulk of the reinforced concrete construction in this country had been carried out with square piles ; round piles were less likely to deteriorate than square ones, as there were no corners. With regard to the rusting of the reinforcement, it was the opening of the pores of the surface of the concrete that allowed the air to get in and rust the steel, and if that could be excluded no rust would take place. He thought it best not to brace piles below water level even if they were as long as 30 ft. To make the concrete impermeable the best thing was to use plenty of cement, and for all work between wind and water nothing weaker than 1 : 1 : 2 should be used and above water 1 : 4 or 1 : 5. For an external coating there was nothing better than coal tar, although it was sometimes difficult to apply.

Mr. H. Jackson said on one job he had found that cracking had been caused by a small piece of unslaked lime getting into the concrete and absorbing the moisture. He thought square piles were less efficient because of the difficulty of obtaining compact and impermeable corners.

Mr. H. A. Reed said the first essential for impermeable concrete was the use of a high silicate cement, and the application of one or two coats of silicate of soda would also tend to improve the face and harden it. In a pontoon built in 1912 of concrete made with cyanite in proportions of 1 : 1¾ : 3½ no water had got inside although it had been in water continuously, and there had apparently been no deterioration between wind and water.

Mr. T. M. Newell (Mersey Docks and Harbour Board) said steel reinforcement was generally put into the moulds as received from the manufacturers, sometimes with the mill scaling still on the bars. That might be one of the causes which brought about early deterioration. To get rid of the scaling he stored the steel to be used in reinforced concrete work for at least three months and then had it cleaned and put into the moulds.

Sir John Griffith said in his opinion the best way to secure impermeable concrete was to use sufficient Portland cement.

Mr. C. H. Sandeman said he had found concrete mixed in the proportions of 1 part cement and 2 parts sand to be quite impervious, and he thought concrete stronger than 1 : 1½ : 2½ or 1 : 1½ : 3 should only be necessary in very exceptional circumstances. Painting bars in reinforced concrete seemed to him to be quite wrong, as the paint would prevent adhesion. There was considerable difficulty in applying coatings of oil to obtain impermeability, and the oil would have to be regularly renewed.

Mr. M. F. G. Wilson said on a job in the East, where there was practically no tide, the underwater bracing of some reinforced concrete jetties was being done by means of steel clips, with satisfactory results.

Mr. C. H. Colson said he thought it was wrong to follow the construction of timber jetties in reinforced concrete jetties, and that new designs should be devised more suitable for the new material. He suggested that the material might be assembled in large masses and thus eliminate the necessity for underwater bracing ; and also that a rustless low-percentage chrome steel might be used.

Mr. R. P. Mears said he had noticed that a harder face was produced when steel forms were used for concrete construction, and if steel forms were used for the construction of tidal works the hard skin might afford some protection.

EFFECT OF WATER ON THE STRENGTH OF CONCRETE.

By **DUFF A. ABRAMS**, Professor in Charge, Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill.

(*Reprinted, with minor revisions by Prof. Abrams, from the Concrete Highway Magazine.*)

Water is one of the essential ingredients of concrete ; a certain quantity is necessary for the chemical reactions of the cement ; an additional quantity is required for the purpose of producing a plastic mass which can be moulded into any desired form.

There are differences of opinion among engineers and contractors as to the influence on the strength and other properties of concrete of differences in the quantity of mixing water used. A thorough experimental investigation of this subject is under way in the Structural Materials Research Laboratory.

The diagram summarises the results of compression tests on 6 by 12-inch concrete cylinders made in mixes ranging from 1 part cement and 9 parts aggregate, to 1 part cement and 2 parts aggregate, by volume. These mixes represent concretes of all qualities from the leanest to the richest which are generally used for any purpose. The aggregate consisted of a mixture of sand and pebbles graded in size from the finest particles up to 1¼ in. ; exactly the same grading was used in all cases.

These tests show that the effect of proportional changes in the mixing water is approximately the same for all mixes of concrete ; consequently a composite curve has been drawn to show the average effect. The vertical distances represent the relative strength of concrete, expressed as a per cent. of the maximum which can be secured from a given amount of cement and the same aggregates. The horizontal distances indicate the relative quantity of water used in the mix, considering the amount which gives the maximum strength as 100 per cent.

The amount of water which gives the maximum strength in concrete produces a mix which is too stiff for most purposes. In plants where such products as building units, drain tile, sewer pipe, etc., are manufactured it is desirable to use a mix even drier than that which gives the maximum strength. The moulds can thus be removed within a short time ; this would be impossible if a wetter and more plastic mix were used.

It will be noted that the concrete strength increases rapidly with the quantity of water over the range indicated by A-B on the diagram. With any further increase in the amount of water there is a rapid falling off in strength, as indicated by the curve BCDEF. With an amount of water double that required for highest strength, the concrete has only about 20 per cent. of the maximum strength.

The exact amount of water corresponding to the maximum strength of concrete will vary with the method of handling and placing the concrete. Any method which involves puddling, tamping, rolling or vibration, or the exertion of pressure in any manner, will have a tendency to increase the strength of the concrete regardless of the amount of water used. The effect produced by these methods is more pronounced in the consistency which gives the maximum strength.

In constructing concrete roads it is necessary to mix the concrete a little wetter than that giving the maximum strength. The consistency which should be aimed at corresponds to about 105 per cent. to 115 per cent. of that giving the maximum strength. In other words, a small portion of the strength must be sacrificed in order to secure a workable concrete. The economics in handling the concrete are more important than securing the maximum possible strength for a given amount of cement.

Many contractors in constructing concrete roads insist on using quantities of water varying between 130 per cent. and 200 per cent. of that corresponding to highest strength. The effect of this practice on the strength of the concrete is indicated by the region D-F on the diagram. It is seen that in this case the strength is being reduced to about 50 per cent. to 25 per cent. of what should be obtained by a proper consistency. The wearing quality of a road constructed in this way is also much inferior to that of a road made from concrete mixed to a proper consistency.

In building construction it is not uncommon to find concrete mixed with a quantity of water even greater than any used in these tests.

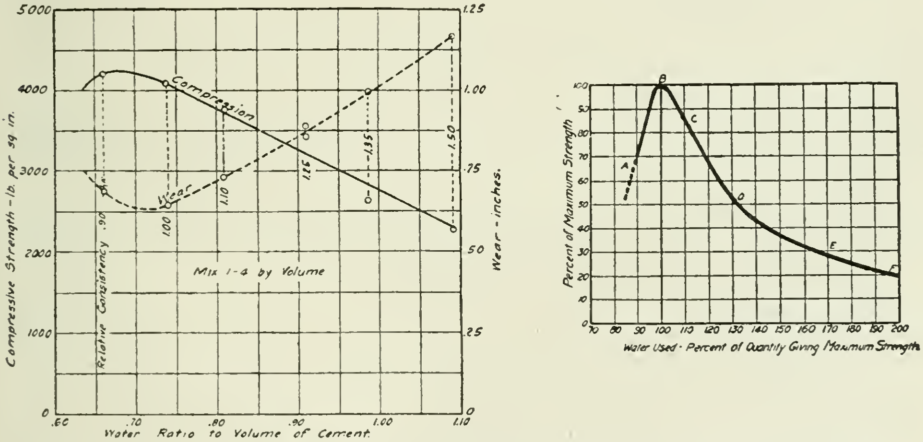
Few engineers or contractors realise the disastrous effects which are certain to accompany the use of too much mixing water. We frequently hear the following reasoning :—

1. The excess water does no harm because it runs off and evaporates.

2. While very wet concrete is weak at early ages it gains in strength more rapidly than the drier mixes.

3. The rich mixes used in road construction are less affected by excess water.

The experimental work carried out in this Laboratory and elsewhere shows that none of these conclusions is correct. The use of excess water produces a concrete which is inferior for all mixes and at all ages. The tests also show that the excess water does not run off until consistencies are reached which correspond to those indicated in the region E-F and beyond. This is indicated by the flattening of the curve which shows that the addition of water beyond that indicated by F has little effect. At this point a degree of " sloppiness " is reached which gives only about 25 per cent. of the available strength.



Curves showing Effect of Quantity of Mixing Water upon the Compressive Strength of Concrete and upon its Resistance to Abrasion. Reprinted from Bulletin 2, Structural Materials Research Laboratory, Lewis Institute, Chicago.

TABLE I

Mix.		Approximate Mix as Usually Expressed.			Water Required (Gallons per sack of Cement).	
Cement.	Volume of Aggregate After Mixing.	Cement.	Aggregate			
			Fine.	Coarse.	Minimum.	Maximum.
1	7¾	1	3	6	8¼	8¾
1	6½	1	2½	5	7¼	7¾
1	5	1	2	4	6	6½
1	4½	1	2	3	5¾	6¼
1	4	1	1½	3	5½	6
1	3	1	1¼	2½	5	5½

The following questions are often asked :

1. What is the proper consistency for concrete road work ?
2. How is this consistency to be determined ?

These questions may both be answered in a nutshell by saying that for road construction the concrete should contain the smallest quantity of water which will produce a workable mix. It is evident that there may be a difference of opinion as to what constitutes a workable mix, but the diagram shows that any reduction in the quantity of water within the range which should be aimed at in concrete road construction is accompanied by a rapid increase in the strength of the concrete.

The proper quantity of water will vary with the quantity of cement and the size and grading of the aggregate, and to a less degree on the nature of the aggregate. The water required for a sand and crushed stone aggregate is not appreciably different from that required for a sand and pebble mixture, providing the grading of the aggregates is similar. In case of very soft or porous aggregates (which, however, should not be used in road construction) a somewhat greater quantity of water will be necessary.

The quantity of water required will depend to a minor degree on such factors as the type of concrete mixer, method of placing the concrete, method of finishing, temperature, etc.

There is no direct criterion for determining in advance the best quantity of water for concrete being placed on a road. The concrete should be mixed so that only a small quantity of free water will appear on the surface after levelling and striking off. This gives concrete of a jelly-like consistency.

The principal difficulty in the way of attempting to determine in advance the proper quantity of water for use in concrete roads, is due to the fact that the aggregates are generally damp, and the degree of dampness is not uniform, but varies from time to time.

In the case of concrete made of sand and pebbles or sand and crushed stone, well graded in sizes up to 1½ in., Table I indicates about the quantity of water which should be used for mixes which are commonly employed.

This assumes, of course, that the aggregates are in a room-dry condition. Any moisture contained in the aggregates on the work must be taken into account. Most sand piled along the roadside will contain from 3 to 10 per cent. by weight of water. In the table the water content is given in terms of gallons per sack of cement. It is not expected that these values can be applied rigidly, since the quantity of water needed will vary with the size and grading of the aggregate, but they may be found useful in suggesting the limits which should be kept in mind in concrete construction.

In the accompanying curve, the quantity of mixing water is expressed as a ratio to the volume of cement in the batch. For example, from Table I the minimum amount of water required for a 1-sack batch, 1 : 2 : 3 concrete, is 5·75 gallons or 0·77 cubic feet. Taking the volume of 1 sack of cement as one cubic foot, the ratio of water to cement would be 0·77. With this ratio the curves shown on previous page indicate a concrete having a compressive strength of approximately 3800 pounds per square inch, and, under the conditions of the tests, a loss by wear of approximately 0·7 inches. Increasing the ratio of mixing water will decrease the compressive strength and increase the loss by wear (or decrease the ability to resist wear). In these curves, each value for compression is the *average* of 20 tests of 6 by 12 in. cylinders with four different curing conditions. Each value for wear is the *average* of 50 tests on 8 by 8 by 5 in. blocks, also under four different curing conditions. All tests were made at the age of 4 months. Under the *best* curing conditions, the concrete will show higher strength and much less wear than any indicated by these curves.

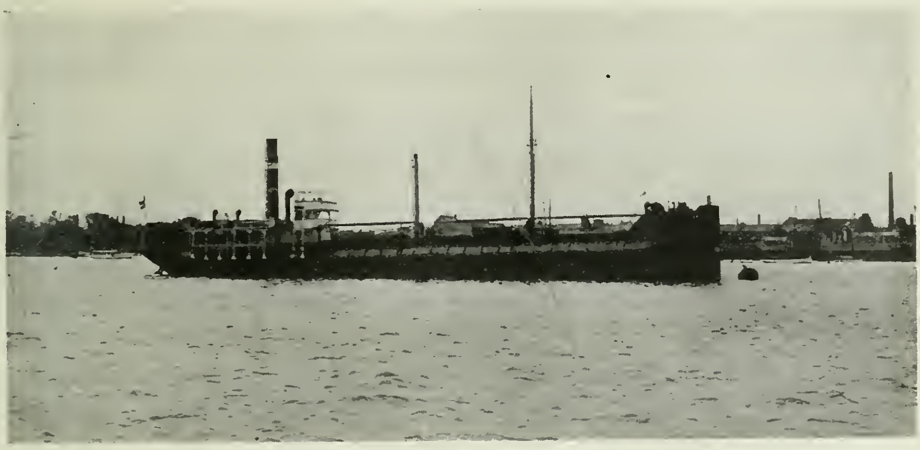


Fig. 1. View of the Completed Vessel.

REPAIRING A CONCRETE VESSEL.

By V. ELMONT, B.Sc., M.I.Mech.E.

In the October number (1920) of this paper the writer gave a detailed description of an 1,800 ton D.W. reinforced concrete ship (see *Fig.* 1) which is believed to be the largest one built in any European shipyard. The vessel measures 231 ft. between perpendiculars, with a beam of 36 ft. 8 in. and a depth (distance between underside of the bottom and the top of the raised part of the deck) of 25 ft. 5 in.; the draught is 17 ft. 6 in., at which waterline the displacement is 3,300 tons, the weight of the concrete hull being 1,140 tons, and of the machinery and equipment 360 tons.

During the heavy gales which raged all over northern Europe during the second week of November, 1920, the vessel was driven ashore on the west coast of Jutland, when it was running with a speed of eight knots, fully loaded. It stranded at a place where the shore is covered with rather large stones, which formed a very uneven and irregular bed for the ship to rest on, much to the detriment of the bottom slab. But apart from the damage done to that slab and the beams directly supporting same, hardly any repair work at all was needed for the main carrying longitudinal trusses.

In the article mentioned it was pointed out that the specially designed double bottom of the vessel would provide great strength and rigidity, though it was built with a relatively very small amount of concrete; and it was further mentioned that any external force acting locally on this bottom would directly be spread over and resisted by a large area of the whole bottom structure. The practical test the vessel has involuntarily been subjected to has fully borne out the expectations in all respects.

The novelty of the bottom design consisted in the arrangement that the upper and lower slabs of the bottom are connected by a number of longitudinal concrete trusses in inclined planes, two and two having top or bottom chord in common, as is depicted in *Fig.* 2 (midship section) and *Fig.* 4 which latter illustration shows the reinforcing bars in place for part of the bottom and of the sides as well.

Soundings taken the day after the vessel stranded gave as results the contours indicated in *Fig.* 3. The WL shown dotted is the one at which the boat floated,

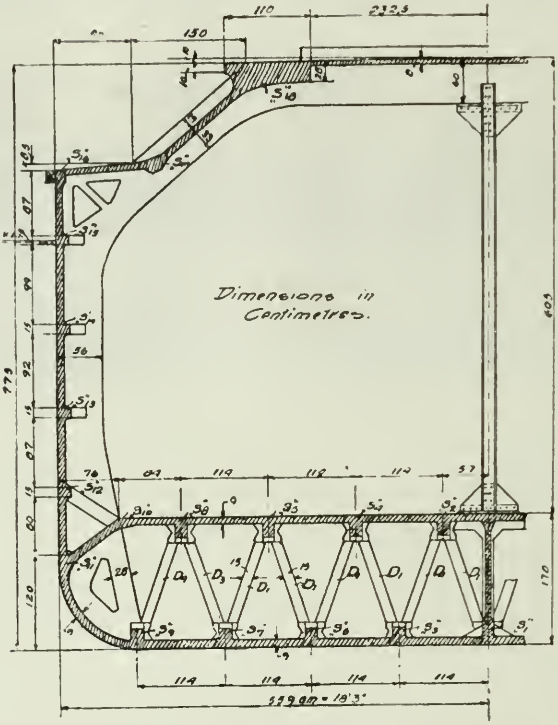


Fig. 2. Midship Section.

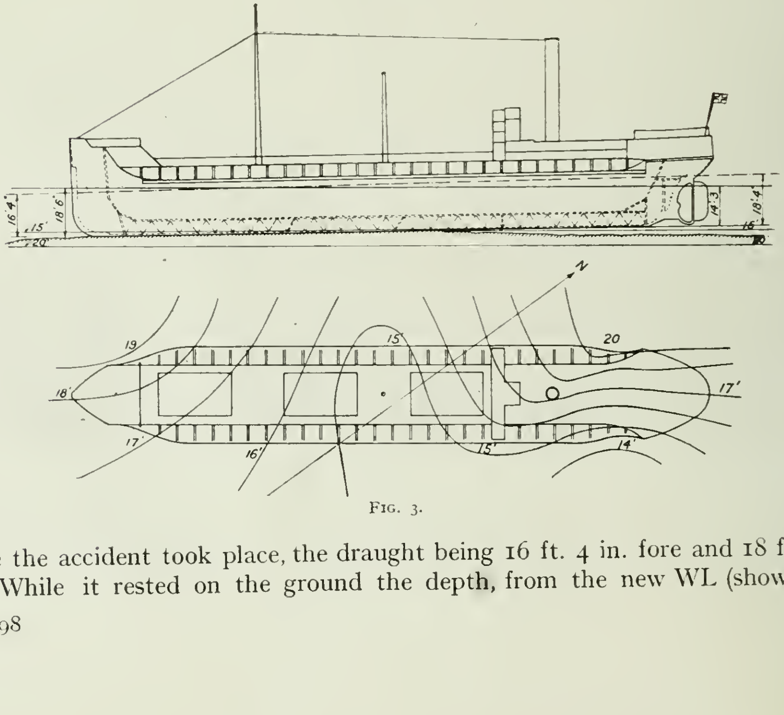


Fig. 3.

before the accident took place, the draught being 16 ft. 4 in. fore and 18 ft. 4 in. aft. While it rested on the ground the depth, from the new WL (shown as a full line) to the underside of the ship was 18 ft. 6 in. at the bow and 14 ft. 3 in. at the stern. In being driven ashore the vessel must have tilted over, leaving the aft part entirely off the ground, as will be seen from the elevation in *Fig.* 3.

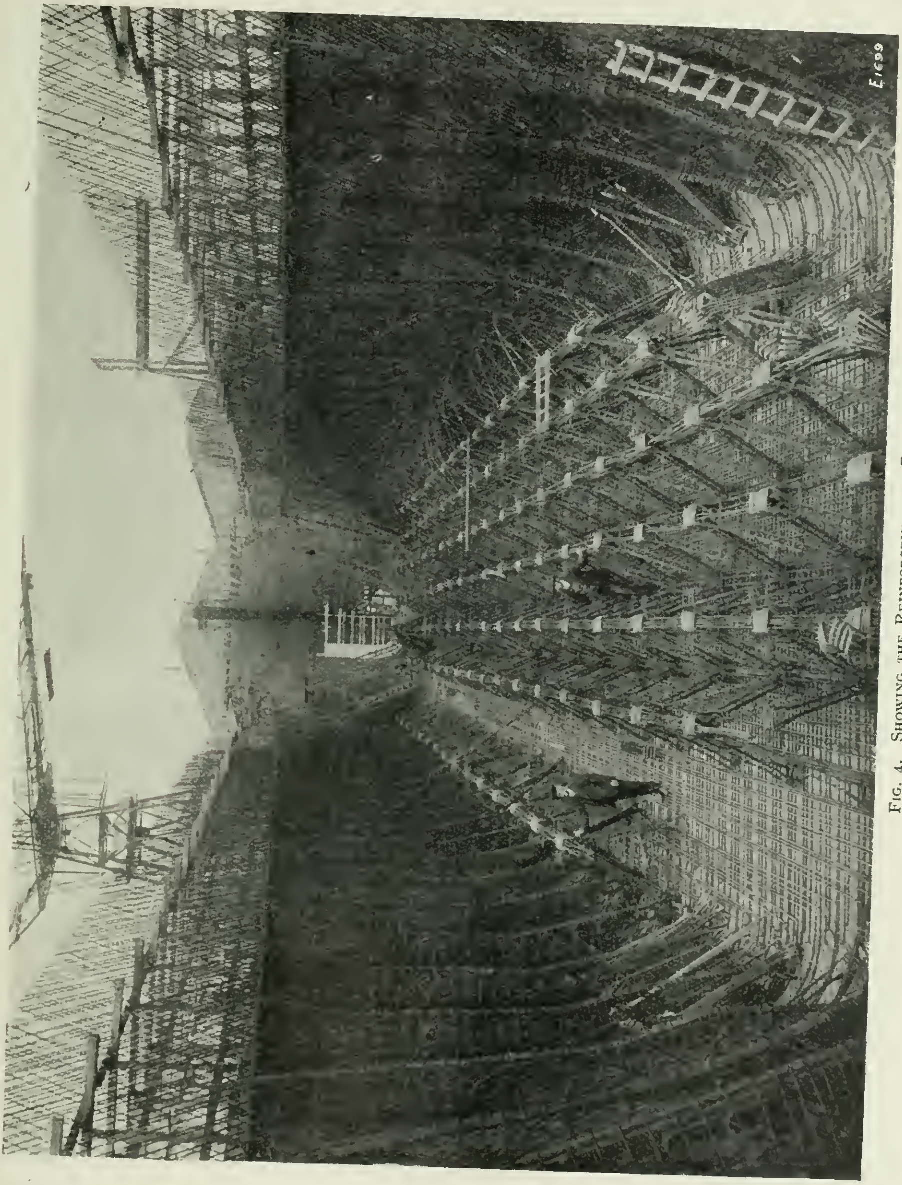


Fig. 4. Showing the Reinforcement in Position.

After part of the cargo had been removed, the vessel left the ground, floating on the upper slab of the double bottom, and, under its own steam, made the journey from the west coast of Jutland to Copenhagen, where it immediately was docked for repair (see *Fig.* 5).

A very careful investigation of the boat gave as result that the upper slab of the double bottom construction showed no cracks at any points, and the diagonals were entirely undamaged, while the bottom slab and stringers bore strong evidence of the extraordinarily severe stresses and strains they had been exposed to during the eleven days the ship was beached.

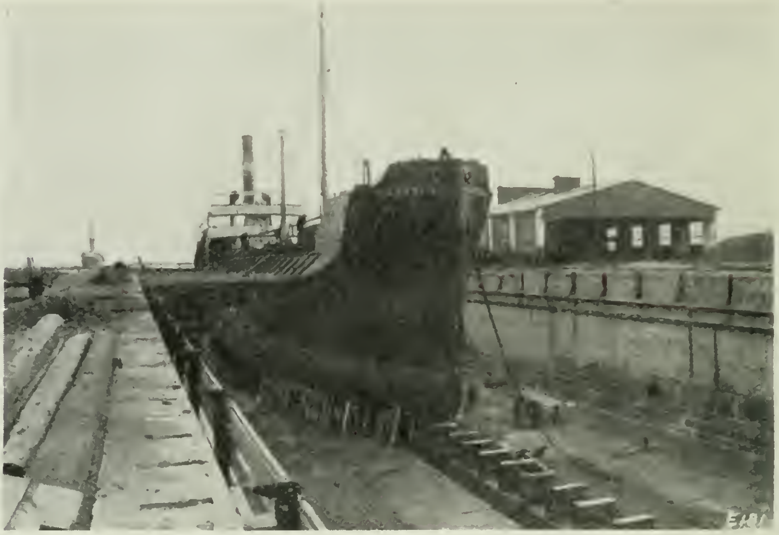


FIG. 5. VESSEL DOCKED FOR REPAIR.

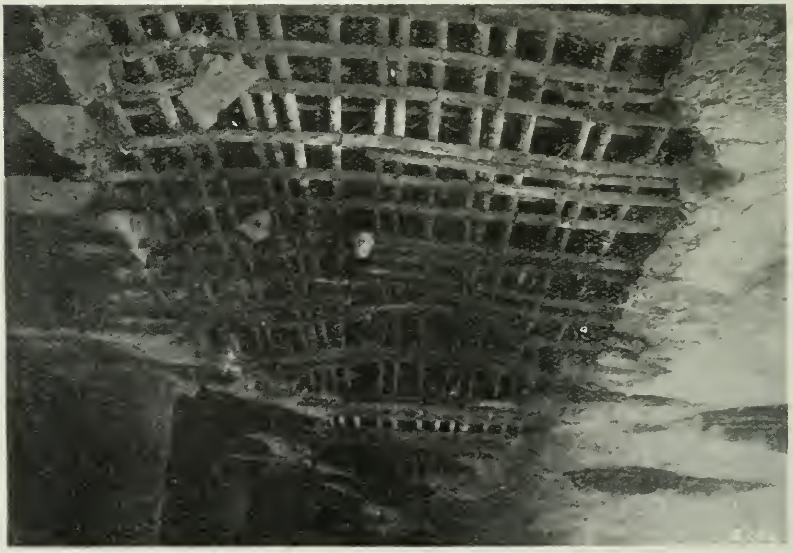


FIG. 6. DAMAGED SLAB AND BARS AT 27–28–C–D.

Fig. 7, showing the underside of the vessel, indicates the extent to which repair work was needed. The slab parts surrounded by heavy full lines were cut out and renewed, but it was actually over a much smaller area—indicated within the chain dotted lines—where the concrete was crushed or holes had formed.

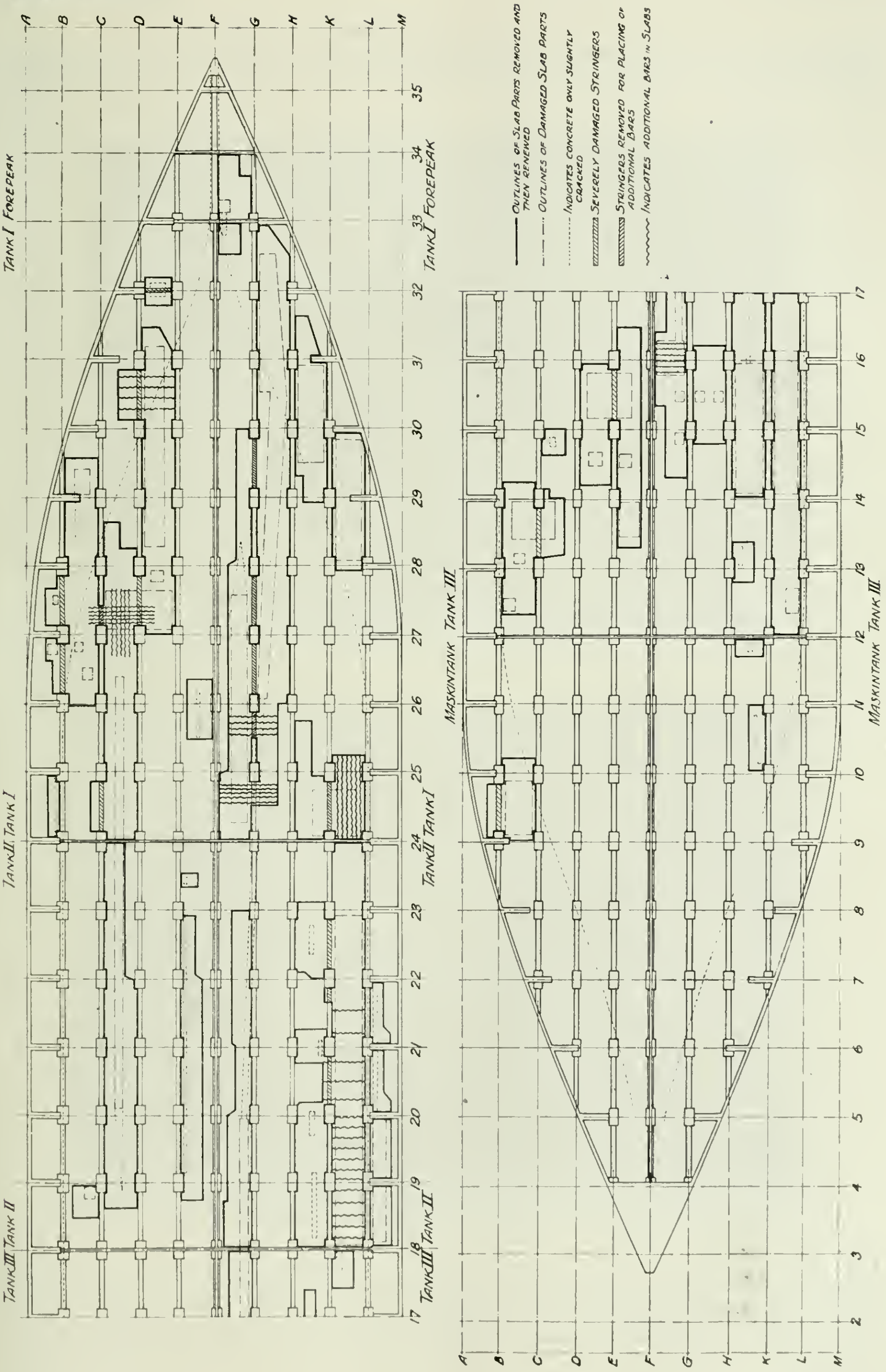

A
B
C
D
E
F
G
H
K
L
M
Tank I Forepeak
Tank II Tank I
Tank III Tank II
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
Tank I Forepeak
Tank II Tank I
Tank III Tank II
Outlines of Slab Parts removed and then renewed
Outlines of Damaged Slab Parts
Indicates concrete only slightly cracked
Severely Damaged Stringers
Stringers removed for placing of additional Bars
Indicates additional bars in Slabs
Maskintank Tank III
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
Maskintank Tank III

Fig. 7.

The reinforcing bars were not broken anywhere ; at a few places they were somewhat bent upward into the bottom, as will be realised from *Figs.* 6 and 8, depicting the damage done at 27–28–C–D (see *Fig.* 6) and 28–30–K–L respectively ; the

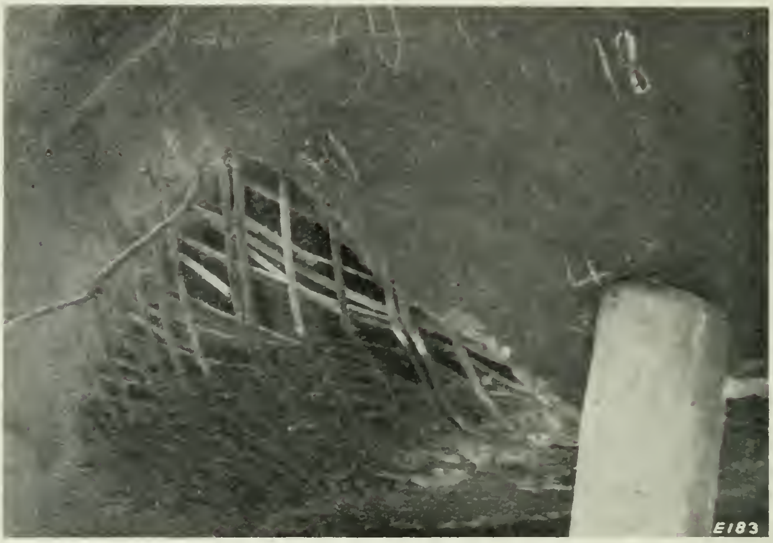


FIG 8. DAMAGED SLAB AND BARS AT 28–30–K–L.

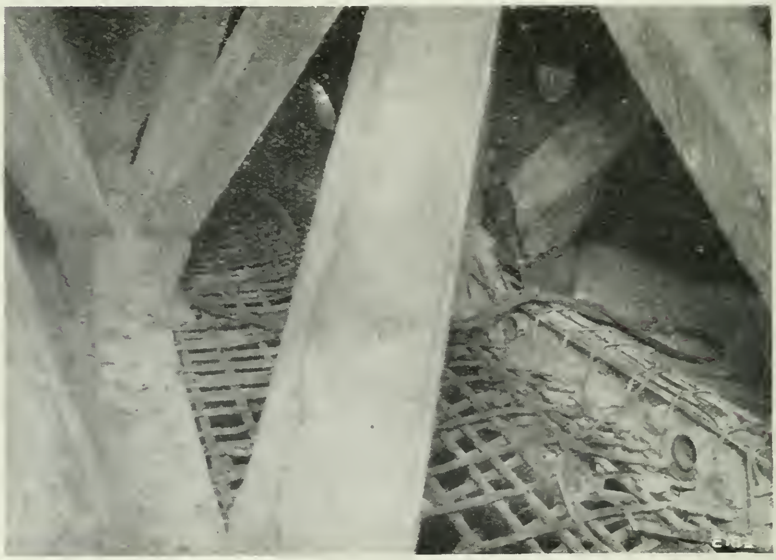


FIG. 9. CUTTING AWAY THE CONCRETE OF A STRINGER.

crushed concrete has been removed and some of the bars have been cut where they were too much bent, and placing of additional straight bars was required.

All the removal of the concrete was done by means of compressed air tools which were found to be extremely useful for this kind of work. They enable the contractors, who were the same that had designed and built the vessel, to complete the repairs within twenty-one working days at a time of the year when short days and inclement weather put innumerable obstacles in the way for obtaining efficient and quick results. In *Fig.* 9 is illustrated the cutting of one of the bottom stringers ; in the adjoining bay the bars were so considerably deformed that they had to be replaced, and in order to obtain sufficient lap length the concrete had to be cut away for a considerable length.

The total area of the bottom which was reconcreted was about 1,800 sq. ft. with about 1,300 lin. ft. of joints in the 3½ in. thick bottom slab between old and new concrete. To obtain watertightness the utmost care was required and exercised, and the repair work was done so successfully that when the vessel was taken out of the dock eight days after the completion of the concreting, the bottom was found to be perfectly impervious. The testing of the tanks, formed between the upper and lower slab of the bottom, was undertaken a few days later, and proved that the upper slab could stand 20 ft. of water pressure without showing any signs of leakage whatever.

The repair work described in the above lines would seem to bear out the contentions of the advocates of concrete ship designers and builders that these ships are less vulnerable than steel ships in case of collision or other accidents, and can be repaired in shorter time almost entirely by unskilled men. In this case it was estimated that the concrete ship could be repaired for about 50% less than a steel ship exposed to the same conditions.

Lyonshall War Memorial.—One of the most favoured forms for the ubiquitous war memorial, is that of a village hall, the inhabitants of many districts feeling that there can be no fitter method of honouring the dead than by ameliorating the conditions of the living.

War Memorial, Lyonshall.

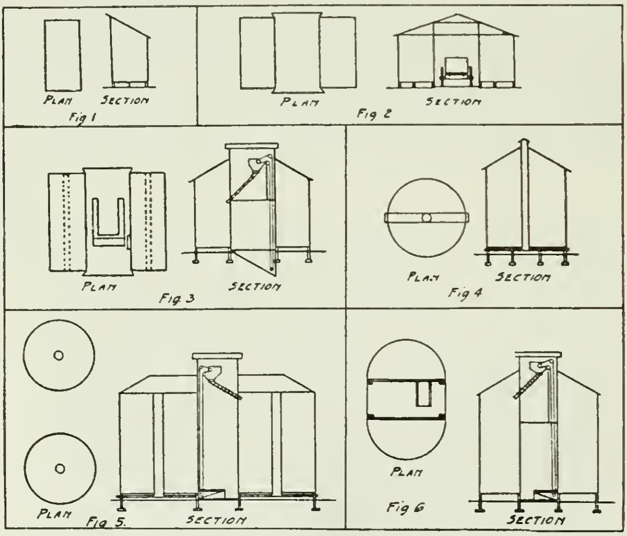
At Lyonshall, in Herefordshire, a spacious parish hall has just been opened which contains on the entrance porch a marble tablet, on which are inscribed the names of the fallen. The hall is built of rock-faced concrete blocks, made with a standard Winget Machine by the Old Radnor Trading Company. It is roofed with Brosely Tiles. The architect is Mr. Richard Morgan and the builder is Mr. William Powell, both of Kington.

CRIBS AND GRANARIES.

The farmer in the United States is realising more and more the need for sound buildings if his farming is to be a profitable business, and there is especially a growing demand in America for the most up to date type of crib and granary. The following report and illustrations which we publish below was recently presented before the American Society of Agricultural Engineers, but although mainly intended for the engineer, there is much in it that will interest the farm contractor and farmer.—ED.

THE object of this report is to present information on the following points, with reference to the design of farm elevators :

1. Some of the different types of buildings that have proven practical for storing ear corn and small grains. 2. The maximum depth and thickness ear corn may be piled without danger of spoiling under average conditions. 3. The percentage of air spaces or openings in corn crib walls. 4. The pressures exerted by ear corn and the small grains in confinement. 5. Methods of building to keep out rodents. 6. Floor construction in cribs and granaries. 7. The various types of shelling trenches. 8. Schemes for ventilating cribs. 9. The usual precautions for preventing rain or snow from blowing into crib. 10. Location of farm elevator. 11. Ways of drying out corn in crib.



FIGS. 1–6. SIMPLE TYPES OF CRIBS AND GRANARIES.

The modern farm crib and granary is generally referred to as a farm elevator; it is of comparatively recent design, and its development has been evolutionary in character, the various stages in its progress being marked by corresponding development in the methods of handling corn and grain. In the early days, when grains were shovelled by hand from wagons, the height of the bin or crib was naturally limited to the height a man could conveniently shovel. The old pioneer type of crib usually consisted of a simple shed roofed structure standing by itself in some exposed position. When more storage room was required another crib was built alongside it, with enough space between the two for a driveway, and both were covered with the same roof. This driveway furnished the man who was unloading corn protection from the winds and storms which, in many cases, was badly needed as the farmer was often compelled to shovel off his load by lantern light after the evening chores were done and the evening meal was over. This sheltered driveway also provided a convenient place for housing vehicles and farm implements. With the advent of power-driven conveyors there occurred a radical change in the design of cribs and granaries. The height was no longer controlled by the height to which a man could shovel; therefore, cribs were built higher to obtain greater economy in construction. Bins for grain and cribs for corn were included under one roof, so that one conveying system would serve to handle all of the farm grains, effecting further economy in construction.

PLAN.

Probably the most common plan for a farm elevator consists of a double crib, with driveway between, and with bins for small grain over the driveway. In the driveway is located the dump or pit and the legs and conveyors for elevating the corn and grain. The cribs are rectangular, semi-circular or circular in form. Quite a number of types of farm elevators of different plans have been perfected. These include (*a*) a circular structure, with crib for corn in the lower section, and with storage for grain in the upper part.

(*b*) A rectangular structure, with two driveways and three cribs (*Fig.* 7). By this arrangement more corn and grain can be handled by one conveyor system.

(*c*) A cross-shaped structure, with two driveways at right angles to each other (*Fig.* 8). This type of crib has little to commend it.

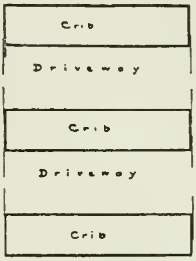


FIG. 7. PLAN FOR 3 CRIBS, WITH TWO DRIVEWAYS.

The circular form is especially suited to masonry structures, as this shape makes it easy to reinforce. There is also an economy of materials as a circular structure will enclose a greater volume for a given amount of wall space than any other form. Circular storages are used singly, in twos or in groups or batteries.

A modern frame farm elevator is shown in plan in *Fig.* 2 and in section in *Fig.* 9. This section shows a crib 30 ft. wide, made up of double cribs 8 ft. 6 in. wide, with 13 ft. driveway. A grain bin, which may be made 14 ft. deep (for oats) is placed over the driveway. The floor of this bin is partly supported by ¾ in. rods, spaced 4 ft. apart, which runs to plate height at sides of bin. Studdings are 2 × 6's, spaced 16 in. o. c. The bin walls are stiffened by tying across with 2 × 10's at plate line. The bin may be partitioned and made into smaller bins or room for grinder, as desired.

The gable ends of this structure are strengthened by tying with a plate made of one 2 × 6 and one 2 × 12 in. member. The studding from lintel over door or floor are 2 in. × 6 in., with two of these replaced by 2 × 10's. These 2 × 10's are spaced two studding spaces, or 2 ft. 8 in. on each side of centre. Two by four studding, 16 in. o. c. are used above plate.

The crib bins are 8 ft. 6 in. wide, with 2 in. × 6 in. studding 16 ft. long. The side walls are tied together by means of 1 in. × 10 in. diagonal bracing spaced 4 ft. o. c., placed about 7 ft. above floor, which allows head room under.

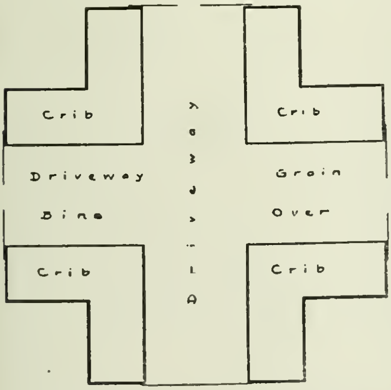


FIG. 8. CRUCIFORM TYPE NOT RECOMMENDED.

Shelling trenches are shown, which serve for sheller drag or a means of ventilating when necessary to dry soft corn. Ventilating flues are made next to small grain bin by placing cribbing boards or lath on crib side of studding.

One of the most recent developments in the masonry farm elevator is a structure made of concrete staves. (See *Fig.* 10.) Staves used for this purpose are similar to those used in the erection of silos, with the exception that each is provided with two openings for ventilation. These openings are each 4 in. wide and 9 in. long, and have four ¼-in. rods embedded in the concrete in such manner that they pass through both openings, forming a grating for excluding rodents. The staves are 2½ in. thick 30 in. long and 10 in. wide. The cribs of this installation are semi-circular in plan, making this structure oblong in shape. Its dimensions are 20 ft. × 30 ft. 10 in. A driveway 10 ft. 8 in. wide runs through the centre. Storage bins for grain are provided over the driveway. A bucket elevator conveys corn and grain to the cupola, from whence it is distributed in the bin desired.

Steel hoops similar to those used on silos serve as reinforcement. The ends of the hoops are rigidly secured to the heavy reinforced concrete door jambs, up to the top of the driveway doors. Above this point the rods are carried continuously around the structure. As the lateral pressure of small grain is greater than that of ear corn, additional reinforcement for the bins was provided in the form of steel channels and "I" beams. These are shown directly over the doorway in the illustration.

A 5-lb. channel on the outside wall is bolted to an "I" beam on the inside. Three such pairs are located on each bin wall over the driveway doors. As a further precaution against possible spreading, the channels on opposite sides of the structure are tied together with steel rods. The channels are also bolted firmly to the corner studs of the grain bin walls.

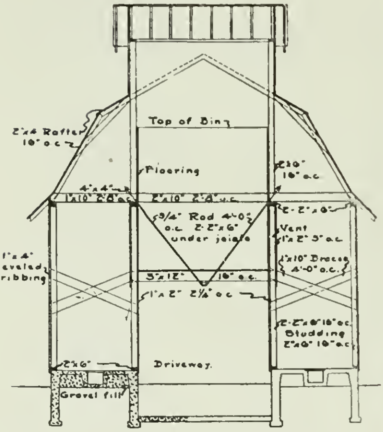
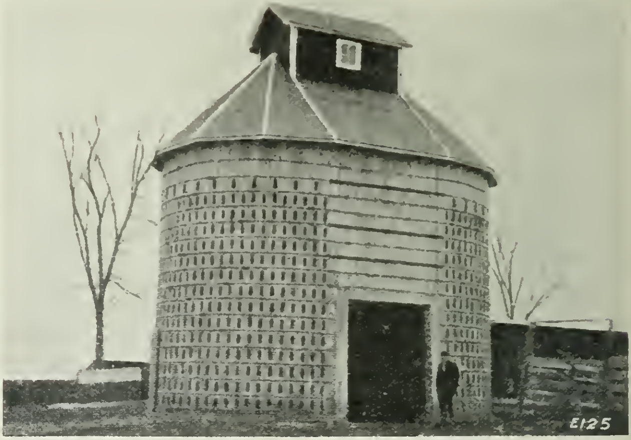


FIG. 9. SECTIONAL VIEW MODERN FRAME FARM ELEVATOR.



[A] FINISHED CRIB.

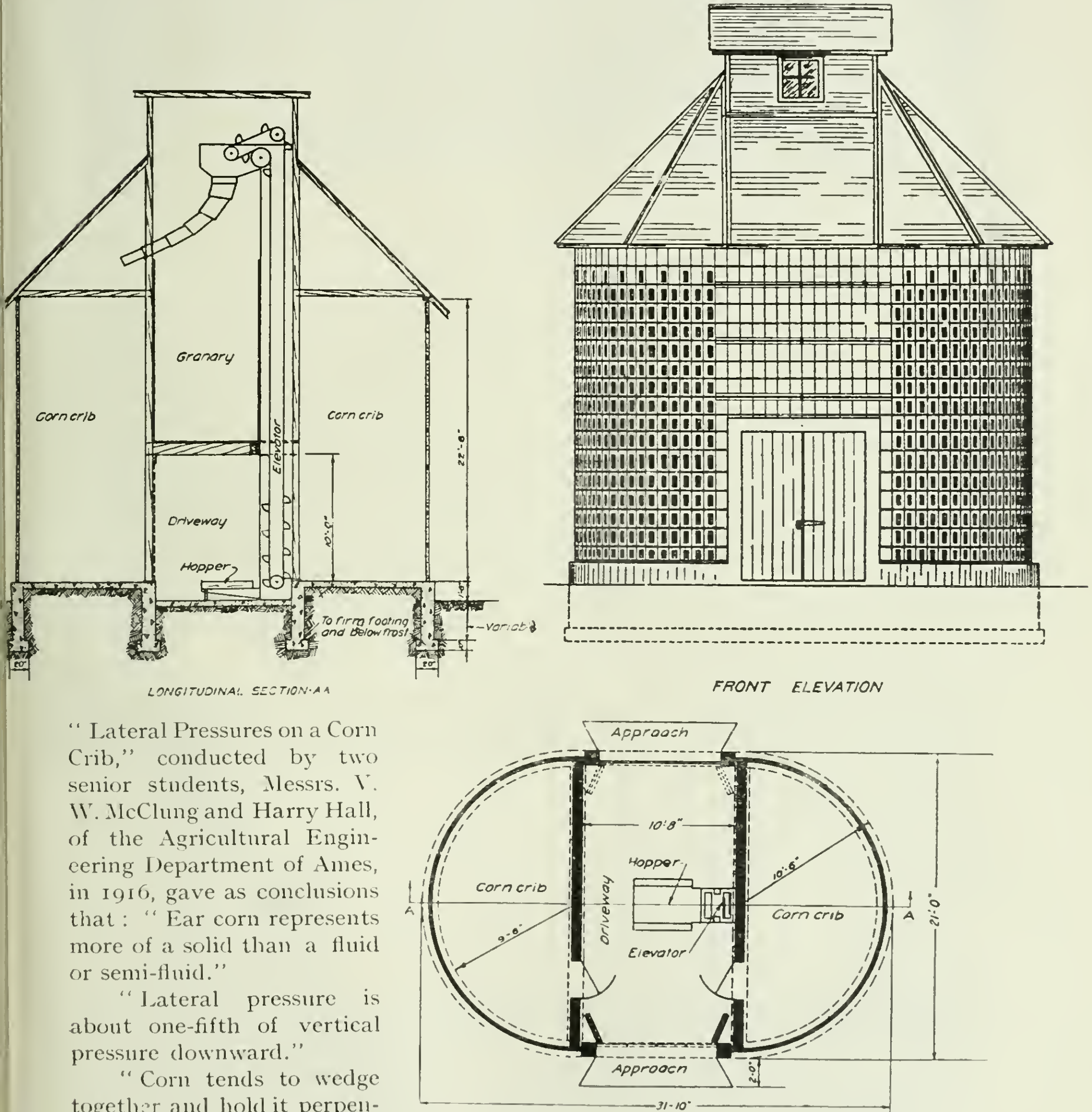
It was found on observing the width of cribs that this varied for different communities. It ranges from 5 ft. to 7 ft. 6 in., while the greater width is found in the corn belt. This greater width is satisfactory in a normal year. It is unsatisfactory, however, for soft corn, and artificial heat or other means must be used to dry the corn.

The openings in crib walls vary from 10 per cent. to 50 per cent. or more. The old cribs built with outside covering, with 1 in. × 10 in. or 1 in. by 12 in. vertical siding, allowed very little air from the outside. In no case would the cracks between boards exceed ¼ in. The driveway side of these cribs was enclosed by 1 in. × 2 in. or 1 in. × 3 in. strips spaced not over ⅜ in. apart. This spacing was usually about ¼ in., or about 10 per cent.

The modern double cribs of the middle west are enclosed with bevel cribbing, usually 1 in. × 4 in. stock. This cribbing, with about 3¼ in. face, is spaced ¾ in. to 1 in. apart. Closer spacing, ½ in. to ⅝ in., may be made, which will discourage rats. This would slightly reduce the percentage of openings, but still give a greater percentage than found in the older cribs. In masonry cribs the amount of air space varies from 20 per cent. to 50 per cent. of the wall area. In general, it is well to provide at least 20 per cent. openings under average conditions.

EAR CORN PRESSURE.

Only a limited amount of data is available on the pressure of ear corn. A thesis, "Lateral Pressures on a Corn Crib," conducted by two senior students, Messrs. V. W. McClung and Harry Hall, of the Agricultural Engineering Department of Ames, in 1916, gave as conclusions that: "Ear corn represents more of a solid than a fluid or semi-fluid."



LONGITUDINAL SECTION-AA

FRONT ELEVATION

FIG. 10. CONCRETE STAVE STRUCTURE OF APPROVED PLAN AND CONSTRUCTION.

"Lateral pressure is about one-fifth of vertical pressure downward."

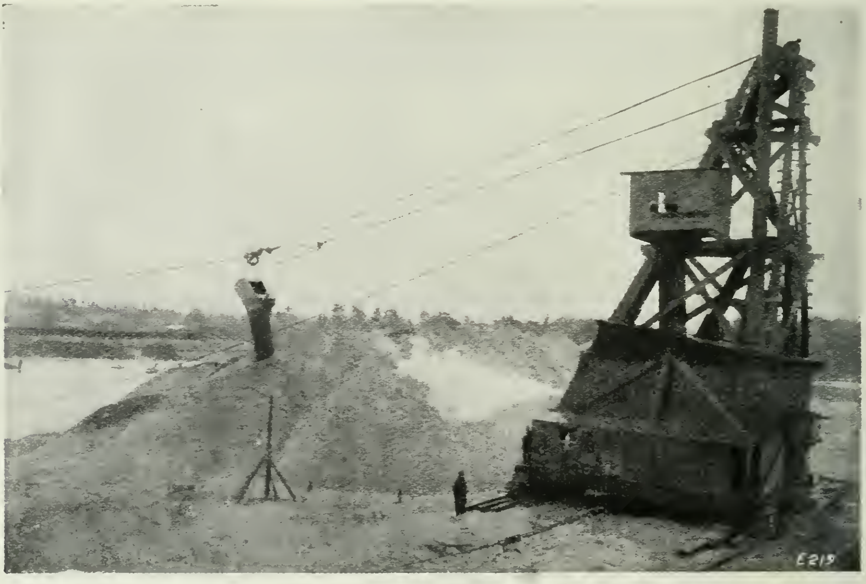
"Corn tends to wedge together and hold it perpendicular, sort of locking rather than flowing, as wheat or the smaller grains."

The crib on which observations were made was a lath stave fencing crib, 8 ft. in diameter and 8 ft. high. It is doubtful if pressure due to ear corn in confinement exceeds 10 lb. per square foot per foot of depth. Cribs designed on this basis have not shown any indications of failure.

Dragline Cableway Excavator Removing Deposits of Mud and Silt from Stream.

EXCAVATING AND CONVEYING PLANT.

Just as the elimination of unnecessary movements in the performance of a specific mechanical operation, each movement small in itself and considered to be not worth troubling about when labour was cheaper than it is to-day, has been proved by Major Gilbrett and others by means of " motion studies " to have a very great effect in lessening the cost of production, so the same principle applied on a larger scale, and involving the elimination of operations complete in themselves, will have a still greater effect in obtaining that ideal at which manufacturers and organisers are aiming, and which will benefit the public and consumers generally, namely, cheap production. The work of excavating for foundations, reservoirs, railway cuttings, etc., has been practically revolutionised during quite recent years, and on up-to-date jobs, and where the use of such plant is possible, the large gangs of navvies formerly employed are now giving way to the more economical mechanical diggers and conveyors. A development of these two types of plant, really a combination of the two, is embodied in the dragline excavator, and although its use is not practical on very restricted sites it has considerable possibilities on large or open sites.



Dragline Cableway Excavator with Fifty-four-ft. Self-supporting Movable Tower.

At this year's Building Trades Exhibition a working model of the "Sauerman" dragline cableway excavator on the stand of Messrs. Hill & Co. (Engineers), Ltd., of 7 Hobart Place, Eaton Square, S.W.1, who are the agents for the plant in this country, attracted much attention. The plant is made in a large variety of designs, suitable for digging either loose or packed material, and whether from a pit or from under water. On many jobs, such as where material is to be dug from one point to form an embankment at another point near by, or where gravel is to be excavated for use in a concrete mixer some little distance away, this type of plant entirely does away with the question of transporting the material as a separate problem, as the four operations of excavating, elevating, conveying, and dumping are all combined in one, and performed by one operator. According to the work for which they are required, the cableways are designed for spans up to 700 feet, and with buckets of varying capacities between one-third and two cubic yards; the buckets are also specially designed to suit the material to be handled. As stated, the whole of the operations are controlled by one man, the cycle of operations being as follows after the dumping of a load. The bucket is released by the operation of a lever and travels by gravity down the cableway to the point of excavation, the speed and stopping being under control. The cable is then slackened and the drum lowered until it comes into contact with the material, when it is pulled forward and filled. When the bucket is full it is raised by the tightening of the cable, and drawn along to the place where its contents are required. The dumping is automatic, and can be at any desired spot along the cableway. The plant can be adapted for operation by any type of motive power.

For work in which material has to be transported for distances up to 700 ft. it is claimed that these draglines effect a large saving, and when the cost of transport and loading and unloading wagons is considered it must be conceded that they have great possibilities in this direction. In America they are extensively used for all kinds of excavating and transporting work, especially in excavating gravel and sand from pits, and, we are informed, a large number are in use by cement manufacturers for conveying lime after it has been grafted and dumping it direct into the kiln.

(*Continued from page* 611.)

Blocking.—It is sometimes desirable to block mixers. Do this whenever possible. It not only prevents destructive vibration, but saves power and repair bills.

Care of Boiler.—If you have a steam-driven mixer, follow these instructions carefully: Do not fire hard when the boiler is cold. The type of vertical boiler best adapted to concrete mixers has one weak point, namely, the top end of the flues is not surrounded by water. In raising steam, the fire should not be crowded until some pressure is shown on the gauge, or the top of the tubes will be overheated and the boiler will surely leak. A boiler is really a sensitive apparatus and requires as much or more attention than the engine.

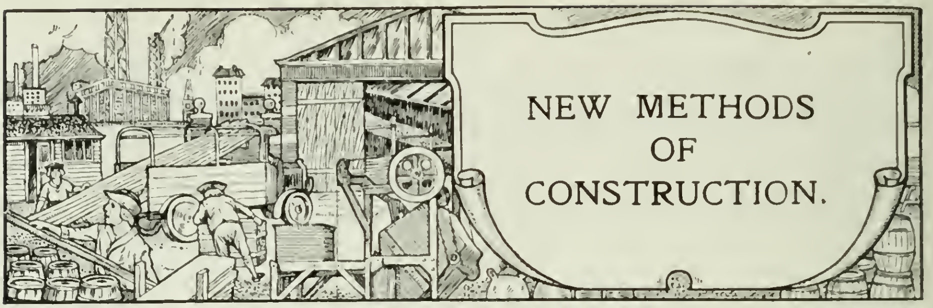
Repairs.—Keep your mixer repaired. Don't allow parts to be worn so that they affect the operation of the mixer. The minute you notice a worn part, order a new one. It will pay you every time. Particularly watch your drum rollers. Replace them as soon as they are worn or become wobbly. Never allow your drum to run untrue. Watch every part and replace it with a new one as required.

Ordering Repairs.—Always keep the repair lists which the manufacturer furnishes. Order your parts by numbers or according to the factory instructions. You will be surprised how much time it will save, and the sooner you get the replacement part on your mixer, the better for the mixer.

These simple rules, if followed carefully, will apply to any make of mixer."

Effects of Crusher Screenings in Concrete.—Tests recently carried out in Canada show a decided advantage in using a proportion of crusher screenings with clean limestone in concrete mixtures. It is, of course, pointed out that no correct general statements concerning the use of limestone crusher screenings could be made without very extensive investigations, but justification is claimed for stating that the presence of crusher screenings in crushed stone up to 20 per cent. is far more likely to substantially increase the strength of the resulting concrete rather than to decrease it.

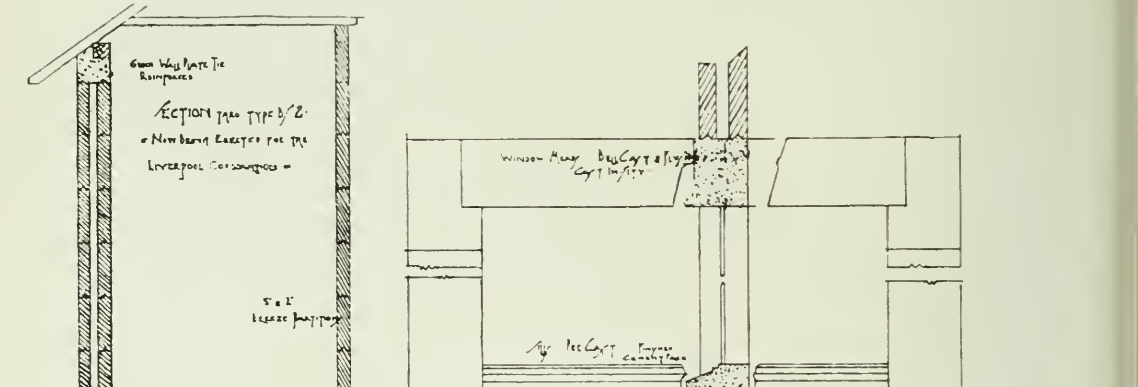
Concrete Pipes at Manchester.—The Manchester Corporation has decided that the northern portion of the Ribble water syphon (four and a half miles in length) shall be constructed of reinforced concrete pipes, at an estimated cost of £206,023. The Waterworks Committee recommended the Corporation to use reinforced concrete pipes on the grounds that there is less danger of incrustation in them than is the case with cast-iron pipes.



NEW METHODS OF CONSTRUCTION.

THE "CALVER" SYSTEM.

In addition to simplicity of erection, the chief advantage claimed for the systems of concrete construction wherein piers are spaced at intervals and the distance between filled in with slabs is the economy in material rendered possible by the fact that all the weight of the upper floors and the roof is carried on the piers. That being so, there is no necessity for the slabs to be of the density and hardness usually employed in concrete block construction, and providing the face is thoroughly waterproofed with cement


Gable Wall Plate Tie Reinforced
Section thro type B/2
Now being erected for the Liverpool Corporation
5 x 2 Breeze Partition
Joist
Pointed face or Bell Cast
Girders Reinforced
Concrete Slab
Internal Partition
Breeze Slab
Window Head Bell Cast & Fly ... Cast in situ
Precast
Isometric showing Method of Fixing
8'
Angle Block
Centre Wall
12 Angle Block
Reinforced
DPC

or other material they may be made of slag, clinker, or other cheaper form of aggregate. In cottage building opportunities occur at frequent intervals to incorporate piers without detracting from the effect or unduly hampering the architect in his choice of design ; in fact, as the piers are an integral part of the construction, they open up many new possibilities in design without adding to the cost.

The " Calver " system (illustrated in detail on p. 610) is a combination of piers and slabs designed on these lines by Mr. G. Calver, of 73 Townsend Lane, Anfield, Liverpool. This method of construction practically consists of a skeleton framework of piers formed of concrete blocks tied together around the whole of the building by reinforced concrete string courses at the first-floor level and at the eaves, this framework being sufficiently strong to permit of the distances between the piers being filled in with slabs which are not required to have any weight-bearing qualities. The piers are built up of blocks 1 ft. 6 in. deep by 8 in. thick and of any desired width, and are spaced apart at distances to conform to the design. The intervals are filled in with slabs 1 ft. 1 in. high by 3 in. thick to form a double wall with a 2 in. cavity. The ends of the slabs are V-shape, and fit into corresponding grooves in the piers, the joints being grouted with slurry. The continuous reinforced concrete string courses at the first floor and roof level rest upon, and transmit all the weight to, the piers. The method of erection is first to lay the lower blocks of the piers, placing the slabs in position as the piers progress upwards. When the walling is completed to the first floor level the string course is placed in position, and the remainder of the walling built as in the lower part until the eaves level is reached, when the second reinforced concrete string course and the roofing is fixed.

Some houses are being erected at Liverpool on this system by Messrs. Perry & Co. (Bow), Ltd., and progress has been rapid, considering the difficulties caused by the coal strike at the time the building was in progress. Work was commenced on these houses on March 19, and with only two skilled men (one mason and one carpenter), the remainder of the operatives being unskilled men, one block was roofed, one block was up to the wall plate, and five blocks were up to first-floor level, by May 11.

MEMORANDA.

The Care of Concrete Mixers.—Mr. L. P. Lessard recently contributed some very useful hints on the care of concrete mixers in the *Contractors' and Engineers' Monthly*. We reproduce his article, slightly abbreviated :—" If contractors would give their mixers the little attention that they require, they would last much longer. . . . The following suggestions for taking care of building mixers are intended as an aid to those contractors who do not, but should, give their mixers careful attention. If followed carefully, good results will be noticeable in the looks and operation of the mixer.

Setting Up.—When you buy a new mixer, see that it is assembled correctly before starting. Turn down the grease-cups, oil the wearing surfaces where necessary, see that the bolts and nuts are tight and be sure everything is all right, then go ahead. Manufacturers always send instructions for setting up, which should be your guide when assembling.

Oiling.—Oil your machine liberally. Give the drum rollers plenty of grease ; they have the heaviest duty. Don't forget your engine, either ; it needs oil. Follow the engine oiling instructions carefully. Oil the drive chains to make them drive smoothly and endure. Oil all gears, especially bevel gears. Use a good quality of machine oil that will not thicken when cold. Also use a good grade cup grease where grease is required.

Feeding.—It has been found that, as far as mixing is concerned, it does not matter in what order materials are fed into the drum. The feeding is done to meet the convenience of the operator. If desired, the old method of hand mixing can be adopted, as follows : sand and cement, then add water and follow with crushed rock or gravel. A good way to get cement in without 'dusting' is to put it into a barrow of sand, or, still better, to add some water to the batch before putting in the cement.

Where a sharp stone is used in the batch, it is well to put in a portion or all of the sand first as the sand will act as a cushion and protect the shell of the drum.

Do not fill the drum too full. A big batch mixes more slowly than a small one. There is a happy medium between best time per batch and best quality, which experiment will determine. Cement mortar or 'sloppy' concrete is best mixed in batches of reduced size.

Washing.—Wash out the drum before the mixer is stopped. It is necessary to keep the inside of the drum clean, as only a clean drum will do good work. Fill the drum with water and revolve it until it is clean, then discharge the water. If water alone does not clean the drum, add a little crushed stone, or a few small pieces of scrap iron. If the drum is once neglected and cement allowed to harden inside, it is very difficult to clean.

(*Concluded on p.* 609.)

QUESTIONS AND ANSWERS RELATING TO CONCRETE.

In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.

Question.—E. G. writes:—Can you tell me whether the Slump Test for measuring the consistency of concrete is standardised? And if so, outline the method for same. What is meant by, say, a 3-in. "Slump"?

Answer.—So far as this test is concerned, it is correct to state that it is not standardised because engineers' ideas as to the correct consistency of concrete differ widely.

The method of conducting the test consists of filling a truncated pyramidal box with the concrete, the box being stood on its wider end. After filling, the concrete is levelled at the top and the box is lifted upward away from the concrete. When this is done, the height of the mass of concrete from the ground is measured and the difference between this and the height of the box represents the "slump." In the absence of any standardisation, the dimensions of the box do not greatly matter, and probably a height of 12 in. with a 12-in. base and 10-in. top would be about the most convenient.

In any given case it is necessary for the engineer to experiment to discover what "slump" corresponds to the consistency of concrete he requires, and then he can specify that this "slump" must be consistent throughout the concrete mix.

PERSONAL.

We have much pleasure in notifying our readers that Dr. Oscar Faber, O.B.E., D.Sc., A.M.Inst.C.E., etc., has recently set up in practice for himself as Consulting Engineer, at 5 South Street, Finsbury Pavement, E.C.2.

Dr. Faber is, of course, well known to our readers by his articles and books on reinforced concrete, as well as the research work he has carrried out on this subject. He is a member of Council of the Concrete Institute, and in addition to his ordinary consulting work he holds the appointment of Consulting Engineer to H.M. Office of Works, the Calico Printers' Association, Manchester, etc. He also is a regular lecturer at King's College, University College, the Architectural Association, etc.

For the last two years this journal has had the advantage of Dr. Faber's cooperation as its Technical Adviser.

"Archibald Dawnay" Scholarships in Civil Engineering.—The late Sir Archibald Dawnay bequeathed a sum of money to the Council for the provision of scholarships tenable in Civil Engineering Courses, and regulations have now been drawn up for the award of the scholarships. One scholarship will be awarded each year to candidates between 16 and 18 years of age who have passed or are exempt from the Matriculation Examination of the University of London. The scholarships will be tenable for two, or in some cases three, years in the course in Civil Engineering in the Battersea Polytechnic, Northampton Polytechnic, or the Finsbury Technical College. Additional institutions at which the scholarships may be held may be approved in future. The maintenance grant provided will be £110 a year, from which the scholar will require to pay his tuition fees, etc.

Candidates will be required to comply with the Council's general scholarship regulations with regard to residence, nationality, etc.

The first award will be made early in the Autumn term, 1921. Application forms (T.2/274) may be obtained from the Education Officer, New County Hall, S.E.1, and must be returned to these offices on or before September 24th, 1921.

CEMENT NOTES.

By Our Special Contributor.

Progress in Cement Manufacture.

THERE are certain subjects which are matters of perennial discussion among cement manufacturers, but upon which there are still many opinions which do not agree. Among such subjects are the comparative advantages of the wet and dry processes of manufacture, the respective merits of rotary kilns and shaft kilns, and the value of tube mills compared with centrifugal mills. It is understood that all these problems are under the consideration of, and in some instances under actual investigation by, the British Portland Cement Research Association, and any definite conclusions that may be reached cannot fail to be of value to the British Cement Industry.

With regard to the choice between wet and dry processes of manufacture it has seemed that the latter is dying out in this country, all new plants being based on the wet process, and some instances of conversions from dry process to wet process being known. In the United States too, the tendency has been similar. With soft and naturally wet raw materials there are few arguments in favour of the dry process, but with hard raw materials containing less than 10 per cent. of water, the saving of kiln fuel on the dry process has to be balanced against the dust nuisance and the difficulty of obtaining an even mixture of ground raw material for feeding the kiln.

A new factor has, however, lately been introduced in the shape of the waste heat boiler applied at the rear end of rotary kilns to recover the heat that is otherwise lost. The waste heat boiler has been adopted at more than twenty cement factories in America, and in numerous cases of the dry process the waste heat from the rotary kilns has sufficed to provide all the steam required for power purposes. This has led to the total fuel consumption for calcination and power being less than 30 per cent. of the cement produced, and has introduced a strong feeling in support of the dry process. The waste heat boiler has also been applied to wet-process rotary kilns with a considerable measure of success, although it is of course impossible in this case to obtain the whole of the steam required for power purposes while retaining a high thermal efficiency in the kiln.

The respective merits of rotary kilns and shaft kilns have probably been discussed in Germany more than in any other country, the shaft kiln being practically an unknown quantity in America, while in England all recent developments have ignored the shaft kiln. The advantages of the shaft kiln are its low capital cost, low fuel consumption, and its easily ground product, while its disadvantages have been high labour cost, tendency to under-burning, and lastly, its dependence on the dry process. The devices for mechanical feeding and discharging of shaft kilns that are being developed bid fair to remove the disadvantage of high labour cost hitherto connected with this type of kiln, and there is no doubt that if shaft kilns could be worked in conjunction with the wet process without undue complications, the cost of cement manufacture would be appreciably reduced. Under present conditions the shaft kiln requires to be fed with solid raw material, and this necessity demands, for all practical purposes, the adoption of the dry process, which adds considerably to the cost when soft raw materials, which could otherwise be washed, are used. If the slurry from the wet process be dried to the solid state, the cost is high and nullifies the fuel economy of the shaft kiln itself. Various mechanical means of removing the excess water from slurry to form a solid "pug," such as filter presses, rotary filters and centrifugal separation, have been considered, and none has commended itself to cement manufacturers owing usually to some feature of high labour, capital or depreciation costs. The field thus still remains open for the invention of a cheap means of producing a solid material from slurry.

The possibility of using kilns of the blast furnace type for producing fused clinker was a favourite subject of discussion with the late Bertram Blount, and although this is an attractive idea, it is very far from practical attainment.

Coming to the respective merits of tube

mills and centrifugal grinders, it is generally agreed that the latter are economical in power, but without the merit of simplicity possessed by tube mills. Simplicity of plant is being further extended by the adoption of the compound tube mill, but to what extent this simplicity is obtained at the expense of power is a subject still requiring investigation.

As indicated at the commencement of this article, there are ample opportunities for research in connection with cement manufacture, and the fact that the British Portland Cement Research Association is at work on the problems that have been touched upon, suggests that British manufacturers will not lag behind in the development of the cement industry.

Concrete Aggregates.

Some excellent work of considerable value to concrete users is being done at the Structural Materials Research Laboratory of the Lewis Institute at Chicago, under the direction of Professor Duff Abrams.

The Laboratory is well equipped, and with a staff of thirty assistants it is possible to undertake research on a larger scale than is attempted anywhere in the United Kingdom in connection with concrete. In some of the investigations the number of test pieces examined has run into thousands, and the conclusions in such cases command greater confidence on this account.

A recently issued report by Professor Abrams on "The Effect of Tannic Acid on the Strength of Concrete" has a bearing on the cleanliness of concrete aggregates, a subject which has previously been discussed in these notes.

Tannic Acid has been chosen as being typical of the organic impurity that is liable to occur in sands and gravels contaminated by surface loams, and the results of some 2,000 compression tests on concrete go to show that very small percentages of such organic impurity have a great effect upon the strength of concrete. The addition of less than 0·1 per cent. of its weight of Tannic Acid to a concrete aggregate may reduce the strength of the concrete containing it to one-half the strength obtained from a clean aggregate, and in a 1 : 4 mix the strength of the concrete is reduced about 15 per cent. when the aggregate contains as little as 1 part of Tannic Acid in 2,000 parts of aggregate.

These results probably explain why some pit gravels with a small proportion of loam—for example, only 2 or 3 per cent.—may produce a worse concrete than other gravels containing 10 or 15 per cent. of loam. The importance of testing pit gravels and sand before use in concrete is thus emphasised, and again we have to acknowledge our indebtedness to the same source for the development of a ready means of testing aggregates for organic impurity.

The test consists of shaking the sand or gravel in a bottle with a 3 per cent. solution of caustic soda and observing the colour of the clear liquid after standing for two hours. The volume of caustic soda solution used should be equal to the volume of the sand or gravel under test, so that after filling the voids in the latter the volume of the clear liquid is little more than half the volume of the aggregate in the bottle.

When the solution resulting from this test is colourless or only light yellow, the aggregate is deemed to be free from injurious organic impurities; when the solution is decidedly yellow the presence is indicated of sufficient organic impurity to reduce the strength of the concrete to a slight extent; while if the solution becomes yellowish-brown or brown the aggregate is considered to be unsuitable for concrete. In the latter case it is desirable to wash a sample of the aggregate and apply the test again to observe whether washing will remove the organic impurity.

MEMORANDA.

Bridge over the Gumtri River.—A reinforced concrete bridge, comprising four spans of 65 ft. each, is to be erected over the Gumtri River in the Shahjahanpur district, Bombay.

Concrete Roads in America.—More than 27,000,000 sq. yds. of concrete roads, streets and alleys have been placed under contract in the United States for the period January to June of this year.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

The Structural Engineer's Pocket Book. By Ewart S. Andrews.

Published by B. T. Batsford, Ltd. 18s. net.

This little pocket book contains some 350 pages, yet manages to retain a conveniently small size so that it can be slipped into the side pocket. The contents have been very carefully selected, and on the whole it is probably the best book of its kind.

It contains first a list of mathematical tables and conversion factors followed by a list of geometrical properties, trigonometrical functions, areas, volumes, moments of inertia, etc. These are followed by the properties of British standard steel sections, which have of course just been revised, and the revised sections have apparently not been included in this pocket book. The next section deals with weights of various sections, strength of materials, working stresses, loads on buildings, bridges, cranes, wind pressure, etc. This is followed by bending moment, and shear diagrams unusually complete for beams freely supported under various conditions of loading, followed by determination of stresses in frame structures by graphical methods and the method of sections, and containing the useful stress coefficients for determining by inspection the loads on members, on lattice girders of various types, and on roof principals of various types. Bending moments and shears in continuous girders are touched on, though this subject is really too complicated for pocket-book treatment. The question of arch design is given considerable space, and is followed by stability of retaining walls and dams, earth pressures, chimneys, silos. Section 5 is devoted to the calculations of columns, foundations and beams, and is good. The author describes in detail his own formula for columns based on assuming that the column is originally slightly bent to a definite eccentricity. Our objection to this formula is that the initial eccentricity assumed is, and has to be, much greater in the case of long columns than actually exists in structures which can be examined; in other words: that while the results may be correct, the assumption is readily assailable, and that in the last resort our only knowledge about the buckling of columns, which is of very practical importance, is the results of tests which therefore ought alone to form the basis of design. In our view, it is quite immaterial whether a curve giving safe stresses to various slendernesses, derived by plotting experimental results, can be put into a simple formula or not since the curve can always be referred to graphically when engaged on actual design.

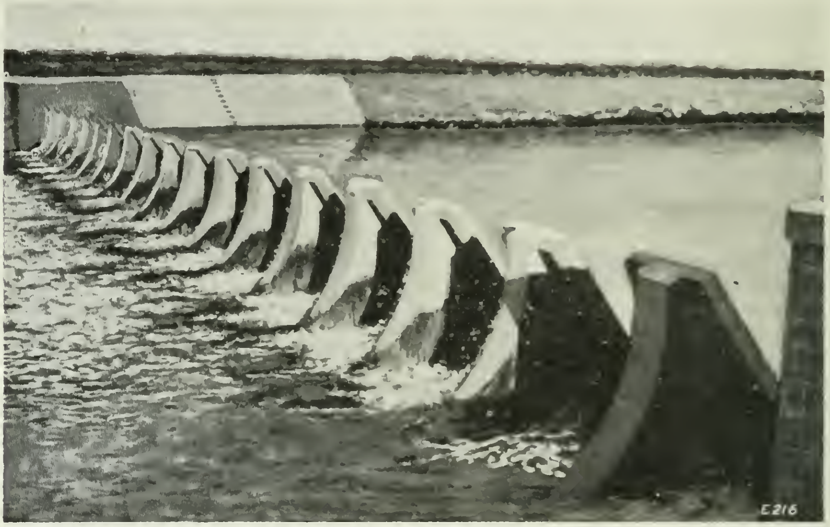
Eccentricities in columns due to beam connections, wind pressures, etc., is dealt with, and the well-known method of graphical determination for the stopping of plates in built up girders is given. The book contains near the end useful details in the construction of roofs, buildings, bridges, followed by the steel frame clauses of the 1909 London Building Act and an index. The book is up to the usual high standard set by the author, and may be thoroughly recommended.

Spraying Concrete Road Surfaces to prevent Rapid Drying.—A suggestion is made by a writer in *Concrete, U.S.A.*, as follows:—When trowelling or finishing a concrete floor exposed to the sun or wind, or under other circumstances when the work is liable to dry too fast to trowel in satisfactory shape, a spray nozzle on a water hose should be used; this gives a fine mist like that produced by nozzles used on grout sprayers, and by concrete products manufacturers in spraying fresh products. This does not make the surface sloppy or make pit marks.

SOME ABSTRACTS FROM THE FOREIGN PRESS.

IRRIGATION IN THE RIO NEGRO VALLEY.

The Rio Negro which traverses a large part of arid land in the Argentine presents many analogies to the Nile in Egypt. It is formed by the junction of the Rio Neuquen with the Rio Limay and flows for a distance of 328 miles through land badly in need of irrigation. The fertilisation of this area is more difficult than that of Egypt because the rise of the water is less regular, both in time and quantity, than that of the Nile.



Notched Fall in the Neuquen Barrage.

A large barrage has now been built across the Rio Neuquen and a divertor excavated to convey the surplus to the Cuenca de Vidal. This barrage has a length of 920 ft. and has 12 spans each of 67 ft. separated by columns each 10 ft. wide carrying a foot-bridge of metal. The openings are regulated by counterpoised sluice-valves of the Stoney type, each 13 ft. high and weighing 32 tons, which move on a series of rollers. These valves can be moved by hand or by motor. The divertor canal is also controlled by a barrage of twelve arches fitted with Stoney valves. Along its length, are three chutes each 3 ft. wide with notched falls, the wall of each chute being at an angle of 30 degrees to the flow as shown in *Fig.* 1. The area to be irrigated is about ten million acres.—*Le Génie Civil.*

TWO SILOS AT ZSCHADRASS.

Two silos of an interesting type have recently been erected at Zschadrass near Colditz and at Sachsenburg near Frankenberg to the order of the Ministry of the Interior of Saxony to plans submitted by Dr. Palen. The silos were erected by the firm of Robert Berndt, Soehne, Dresden.

Whilst the construction of a silo of brickwork may appear to be cheaper because it requires no shuttering, yet the construction is in practice confined to circular silos, whereas concrete silos can be of any desired shape.

Both the silos under consideration are built with walls only 4 in. thick, yet they have proved quite durable and the ensilage is reported as being of excellent quality and quite unaffected by an exceptionally cold winter.

Instead of a door below, as is customary, these silos have a slit 2 ft. wide extending from top to bottom on both sides. This slit is covered by boards inside the silo and enables material to be withdrawn at any desired level. To obtain ensilage of the best quality it is essential to avoid irregular packing of the silo and the latter is almost inevitable when the silos are emptied solely from below.

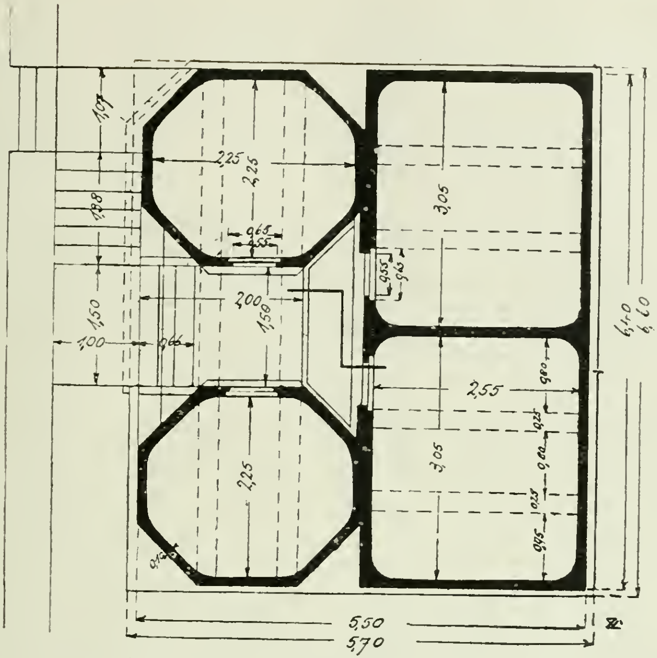


Fig. 1. Plan of the Silo (*measurements in metres*).

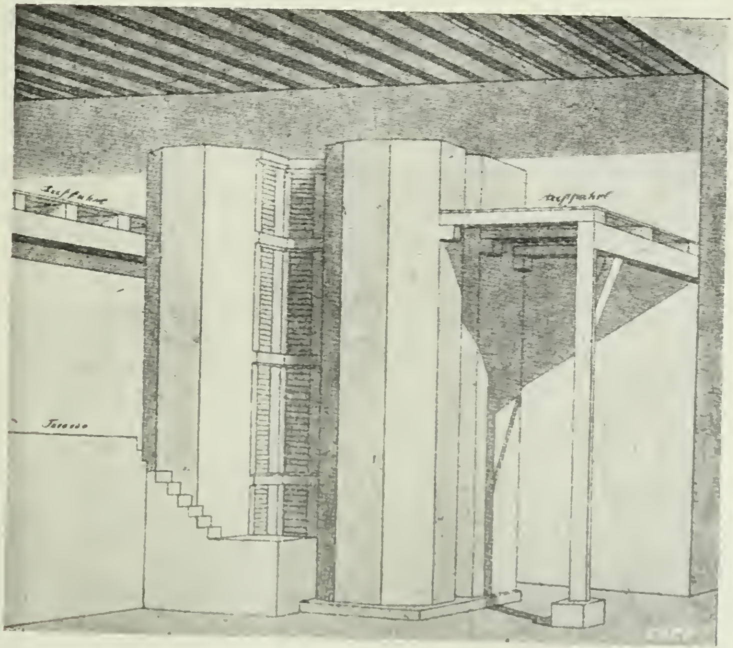


Fig. 2. Perspective View of the Silo.
SILO AT SACHSENBURG.

Silos should also be grouted internally so as to give a smooth finish which will not be affected by the lactic acid produced from the ensilage.

The silo at Zschadrass has a capacity of nearly 120 cub. yds. It is 20 ft. high and in plan is an extended octagonal resembling an ellipse whose major axis is 15¾ ft. and the minor axis 11¾ ft. internally. This shape was due to local conditions as to space. The rapidity of construction was such that the silo was ready for use exactly sixteen days after the receipt of the order ; the total cost was 2,300 marks, which is considered low as all the materials had to be carted over two miles from the nearest railway. The walls are designed as vertical beams.

The silo at Sachsenburg consists of four cells—two rectangular ones each with a capacity of 93 cub. yds. and two octagonal cells each of 60 cub. yds. capacity, i.e., a total capacity of 300 cub. yds. The use of several cells has the advantage of keeping different ensilages quite separate. This silo has an internal height of 30 ft. The lower entrance is 9 ft. above its base and the top of the silo is 5 ft. above the upper entrance so as to enable the silo to be filled direct from the wagons. The outlet slits of the cells open into a niche 9 ft. long and 5 ft. wide to which access is gained by a stairway.

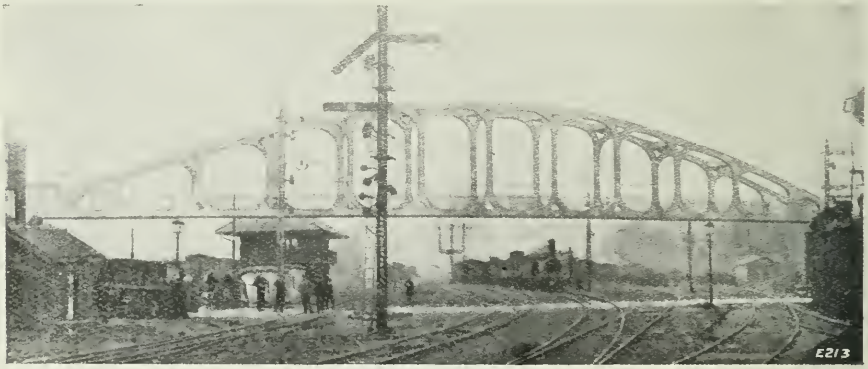
Above each cell and above the niche just mentioned lie two or three concrete beams each 8 ft. wide, above which planks may be laid in order to better distribute the ensilage. Drainage is provided for (if required) by a channel and pipe in the bottom of each cell. This silo cost 21,800 marks.—*Zement.*

A LARGE SPAN BRIDGE AT LA LOUVIÈRE, BELGIUM.

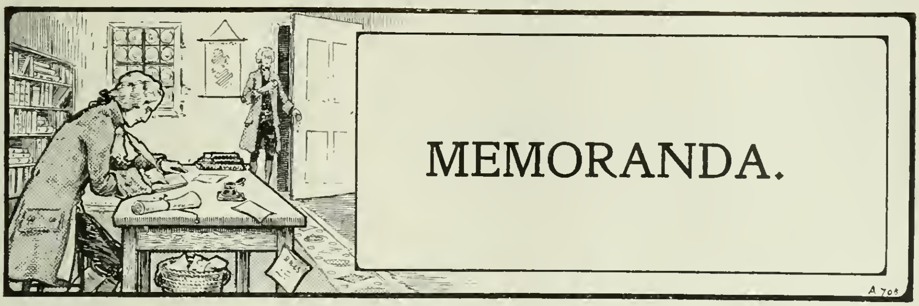
Considerable interest attaches to a reinforced concrete bridge designed by Prof. A. Vierendeel with a span of 186 ft. which crosses the railway at the La Louvière station in Belgium. The height of this bridge is 24 ft. at the centre. It is calculated to carry a load of 80 lb. per sq. ft. and a wind pressure of 30 lb. per sq. ft. The estimated cost (frs. 22,800) was 25 per cent. below that of a suspension bridge and 45 per cent. below that of a lattice girder bridge and the actual cost agreed well with the estimate.

The lower flanges have a scantling of 16 in. high by 12 in. deep ; all the uprights have the same scantlings, viz., 16 in. on 12 in. and the upper flanges 18 in. on 12 in. The union of the uprights and the flanges is quite complete so that Vierendeel's formulæ are strictly applicable. The structure is supported on expansion joints and is quite free from cracks.

The test load of 80 lb. per sq. ft. was applied by means of sacks of gravel each weighing 1 cwt. The deflection at full load was only 0·5 in. as against 2¼ in. allowed by the designing engineer. Two hours after the removal of the load no deflection at all was shown. When twenty-five workers marched in step across the bridge and back again the maximum amplitude of vibration was 0·12 in. ; when they were collected at the centre and jumped in unison the maximum deflection was 0·2 in. So successful has been the bridge just described that another one 420 ft. span and 80 ft. high is contemplated.—*Le Génie Civil.*



Bridge at La Louvière.

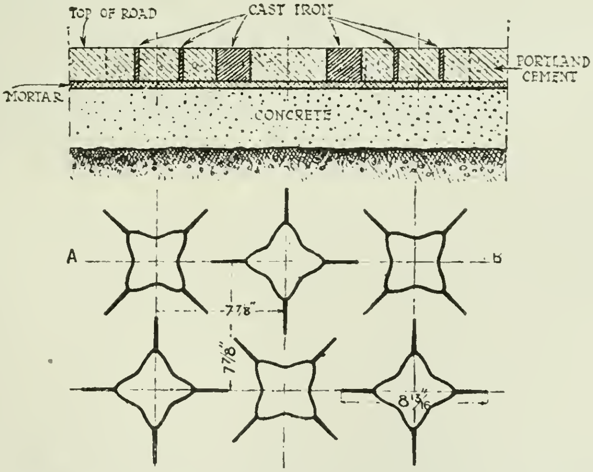


MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—Ed.

Roads in France.—In a previous number we referred briefly to a method of concrete road construction that was being adopted in France in the City of Lyons at the Pont-à-Mousson Steelworks.

Method.—The essential feature of this road is the use of cast iron in conjunction with concrete, forming what may be described as an armoured concrete road. A concrete foundation about 4 in. in thickness is covered with a surface dressing of Portland cement, and while this is still soft it receives the cast iron members shaped as shown in the accompanying illustration, and having a height of $1\frac{3}{4}$ in. The elements weigh about $1\frac{3}{4}$ lb. each, and are laid from sixteen to twenty-five to the square yard, according to the intensity of the traffic. The metal surface is then covered with fine concrete, which is laid before the cement surface is quite dry, and is finally well stamped down and left to dry slowly.



The above sketches show the method of construction adopted for the experimental cast iron and concrete road laid in one of the streets of Lyons, France.

Condition.—The street in Lyons selected for experimental purposes is one carrying very heavy traffic, for it is opposite the main goods station, and as there are no tram-lines it is preferred to other arteries by drivers of heavy lorries. A report has been issued by the municipal road engineer after six months' service, and is on the whole very favourable towards the new system. It is stated that the cast iron elements, which were covered when the road was quite new, are now visible, and that they project very slightly, but do not offer any inconvenience to traffic. For all practical purposes the surface may be considered as perfectly smooth; it gives off less dust than the surrounding granite-paved streets, and it allows water to run away readily.

Cost.—The cost of construction of this road is stated by the municipal engineer to have been 26 frs. 70 per square metre, but this price is higher than normal, owing to the fact that the men had had no previous experience in this type of road paving. After the first portion of the road had been laid, the cost was reduced to 25 frs. per square metre, and it could be brought down even lower. As a matter of comparison, the Pont-à-Mousson Steelworks give the pre-war cost as 19 frs. per square metre, compared with 22 frs. 6 for asphalt, 22 frs. 65 for wood, 23 frs. 86 for granite on sand, and 26 frs. 60 for granite on concrete. They claim that the annual maintenance cost for the armoured concrete road is practically nil compared with other systems of road-making.

A Race Track for Paris.—We understand Paris is to have a race-track, modelled more or less on the Brooklands pattern. The track has been planned on comprehensive lines, and, judging by its long straights, with a view to exceptional speeds. If all goes well the track will be opened to the public next summer. The track will be over 4¾ miles to the lap. The surface is to consist of a concrete foundation, a layer of end-set bricks, and a top-dressing of concrete.

Concrete Pipes in Australia.—It is reported that the Government of South Australia has awarded the Hume Pipe Co. (Australia), Ltd., a contract for the laying of concrete pipes over an area of 130,000 acres near the Murray River, between Murray Bridge and Adderley, at a cost of about £3,000,000, in connection with an irrigation scheme.

Concrete at the Yorkshire Agricultural Show at Leeds.—This was a three-days show commencing on July 20. The attendance on the opening day was a record one, and large crowds visited the show on the second and third days.

Concrete, which is becoming ever more popular for use in connection with agriculture,. was represented by Messrs. Girling's Ferro-Concrete Fencing Company, of Morley, near Leeds. As the name implies, this Company has specialised in concrete fencing, and their exhibits at this Show were one of the centres of interest. Various types of concrete fencing and gate posts were exhibited, one of the latest being a low fence especially adapted for Housing Schemes.

A pair of gate piers and ornamental entrance gates, which occupied a central position on the stand, attracted considerable attention. These were 8 ft. above ground and 15¾ in. square, panelled, and with stopped chamfered edges.

The fact that this firm does not confine itself to fencing alone was shown by two other exhibits—a garden frame and a pigsty, both made of pre-cast concrete slabs and bolted together. In the latter case the idea is that it shall be a tenants' fixture, an important consideration with the smallholder.

There is no doubt that Messrs. Girling's exhibit opened the eyes of a good many to the utility of concrete on the land.

Concrete machinery manufacturers were represented by Messrs. William Benson & Co., Phœnix Works, Meanwood Road, Leeds, who are agents for the Australia Concrete Block-making machine. The exhibits consisted of three of these machines which will turn out either plain slabs or T-blocks, a Tonkin concrete mixer with power attachments, and various examples of walling made with the aid of this machinery. One of these examples was a corner consisting of blocks sand-faced and backed up with concrete containing ordinary rough aggregate.

New Offices for Bevan Cement Works.—The accompanying illustrations show the new offices for the Bevan Cement Works at Northfleet, Kent, and these offices are constructed of concrete throughout, including the window frames.

The building rests on a concrete raft, 9 in. thick, the concrete being a 4 : 2 : 1 mix and Expanded Metal Diamond Mesh having been used for the reinforcement.

The walls of the building are 2 in. cavity walls consisting of concrete blocks made on a Winget machine, the blocks for the external walls being of cement ballast concrete in the proportion of 6 : 1 while the inner leaf consists of breeze blocks. Wall ties were used to tie the inner and outer face of walls, the ties being 4 ft. apart horizontally and 9 in. apart vertically.

The concrete window frames constitute an interesting feature of the building; they are pre-cast on the "Marriott" patent and were delivered on the site ready for fixing.

The porch is of concrete and cast cement work.

7 : 1 Portland cement chamfered skirting has been run around all walls.

The strong room has also been built of concrete and erected *in situ*. The room

is ceiled in concrete 9 in. thick and there are four 3 by 2 iron joists running through same. The inside face of the walls was rendered in cement.

As will be seen from one of the illustrations a concrete road has been laid outside the building.

Supply of Building Materials.—Arrangements are in force between certain Associations of Manufacturers and the Department of Building Materials Supply, under which materials are supplied to the Government for housing schemes at a discount or rebate below the current Market price. These concessions in price have been granted for Housing Schemes only, and will not remain in operation after the Department has been brought to an end.

The modified arrangement has been agreed in the case of *cement* by firms in the Cement Makers' Federation and certain firms who are not members of the Federation, and in the case of *Sanitary Ware* by firms in the Enamelled Sanitary Fireclay Makers' Association.

These firms have agreed to continue the special concessions in price to the Government for Housing Schemes only, and have accepted the alteration in procedure for a limited period, in order to facilitate the work of winding-up the department.

Supply of Cement.—The following revised arrangement will be in force as regards all consignments delivered on or after the 1st September, 1921, and before the 1st April, 1922 :—

1. All requisitions for cement for Housing Schemes should be sent to the Department of Building Materials as heretofore.
2. The Department will place the order with the Makers (special measures being taken to avoid delay), and will send to the Local Authority a copy of the delivery instructions, on which the price will be stated.
3. The cement will be invoiced to the Local Authority by the Makers on D.B.M.S. Form P. 1955 at a special rebate of 3¾ per cent. below schedule price.
4. The Consignor's advice of despatch and the Building Contractor's acknowledgment of receipt (D.B.M.S. Forms 1026) will be sent to the Local Authority instead of to the Department of Building Materials Supply.
5. The arrangement will terminate on the 31st March, 1922, after which Local Authorities or their Contractors will make their own arrangements.

CONCRETE AND HOUSING SCHEMES.

Ashton-under-Lyne.—Plans of two concrete houses, to be erected at Toothill Farm by the Lancashire County Council, have been approved by the Ashton-under-Lyne Urban District Council.

New Mills.—The New Mills Urban District Council has received seven tenders, ranging from £2,628 to £1,512 per pair, for the erection of concrete houses, and these have been sent to the Housing Commissioner.

SOCIETIES.

The Royal Institute of British Architects.—RESULTS OF SUMMER EXAMINATIONS. The following candidates passed the recent Final and Special Examinations of the Royal Institute of British Architects :—

Mr. R. W. Ferguson ; Mr. J. M. D. Henderson ; Mr. L. W. Ingham ; Mr. J. A Kerr ; Mr. C. M. Master ; Mr. D. J. G. Plumley ; Mr. F. I. Tellery ; Mr. F. Wilkinson ; Mr. J. Williamson.

The Ashpitel Prize (£10 in books) has been awarded to Mr. L. W. Ingham, and a mark of distinction has been awarded to Mr. F. I. Tellery for his Thesis.

TRADE NOTES.

Messrs. Browne & Tawse, Ltd.—We are informed that the Road Section of Messrs. Browne & Tawse, Ltd., which was closed down pending the action for an injunction brought by the British Reinforced Concrete Engineering Co., Ltd., against Mr. A. W. C. Shelf, the manager of that particular department, has now been reopened, consequent upon the decision of the Court of Chancery in Mr. Shelf's favour. The Road Section is now being carried on under the direction of Mr. G. H. Hoile, as before, and Mr. Thomas L. Farrar is the sole selling agent for the south-eastern district of the United Kingdom, his present address being 3, London Wall Buildings, E.C.2.

Winget Limited, whose concrete block-making plant has been one of the features of the International Exhibition of Architecture and Housing held this summer at Ghent, have received the Gold Medal of the Belgian Crown Prince—the highest award at the Exhibition.

Pneumatic Road-Breaker.—A pneumatic road breaker for breaking up concrete foundations has lately been used on some of our roads. Briefly described the pick point of this appliance is fixed into a vertical cylinder and forced by compressed air, fed through rubber piping from a portable compressor, an invisible hammer strikes the head of the pick point about 500 blows a minute, and under this great pressure it appears to slide into the concrete which is broken into small lumps. Only two men are required to place this machine into position. This roadbreaker is being put on the market by the Ingersoll Rand Co., 165, Queen Victoria Street, E.C.

PROSPECTIVE NEW CONCRETE WORK.

Alsagar.—*Waterworks.*—The Ministry of Health has held an inquiry into the application of the Alsagar Urban District Council for sanction to borrow the sum of £6,000 for extensions at the waterworks.

Batley.—*Reservoir.*—The Batley Corporation Bill, which provides for the extension of the water supply undertaking by providing for the construction of an additional storage reservoir of 290,000,000 gallons, has been passed by the House of Lords.

Beddington.—*Sewage Works.*—New sewage works are to be carried out at the Beddington sewage farm, at a cost of £20,000, by the Croydon Corporation.

Cricklade.—*Tank.*—In connection with a new water supply scheme, the Cricklade & Wootton Bassett Urban District Council has decided to construct a tank of 2,000 gallons capacity.

Dufftown.—*Reservoir.*—The Dufftown Town Council has decided to borrow £1,500 for the construction of a new reservoir.

Dundee.—*Harbour Works.*—The Dundee Harbour Trustees are considering the question of carrying out improvements at the harbour, at a cost of about £150,000.

Dundee.—*Road.*—The Dundee Town Council has received Parliamentary sanction to proceed with the erection of a new road and sea wall at Broughty Ferry, at an estimated cost of £206,000.

Durham.—*Roads.*—The Durham County Council has decided to carry out several road widening schemes, and the construction of concrete walls, in its area, at a total cost of about £30,000.

Easington.—*Water Supply.*—The Ministry of Health has held an inquiry into the application of the Easington Rural District Council for sanction to borrow £56,000 for extensions at the waterworks and for the extension of the water supply to several parishes.

Flintshire.—*Road.*—The Ministry of Transport has sanctioned the construction of a new trunk road from Gronant to Rhyl, Flintshire, at a cost of £37,000.

Greenock.—*Roads.*—The Greenock Corporation has decided to proceed with the construction of two new roads (East Hamilton Street and Port Glasgow Road) at an estimated cost of £33,375.

Greenock.—*Wharf.*—An extensive scheme for the improvement of the shipping facilities at the port is being considered by the Greenock Town Council. It is proposed to erect a deep-water wharf at the end of the Princes Pier so as to accommodate ships engaged in the Transatlantic trade.

Hessle.—*Concrete Tubes.*—The East Riding County Council has decided to replace the brick culvert under the road between Hessle and Hull with concrete tubes.

Hucknall Torkard.—*Reservoir.*—The Hucknall Torkard Urban District Council has decided to construct a new reservoir.

Ilkeston.—*Water Tower.*—The Ilkeston Corporation has decided to erect a water tower at Shipley, at a cost of £6,000. The tower will be 40 feet in height.

Millom.—*Reservoir.*—The Millom Urban District Council is considering a scheme for the construction of a new reservoir.

Ormskirk.—*Road.*—The Lancashire County Council is considering the construction of a by-pass road at Ormskirk, at an estimated cost of nearly £70,000.

Oxfordshire.—*Bridge.*—The construction of a new bridge at Goring, at a cost of about £31,000, has been approved by the Oxfordshire County Council.

Royton.—*Sewage Works.*—The Royton Urban District Council has applied to the Ministry of Health for sanction to a loan of £16,000 for sewage disposal works.

Southend-on-Sea.—*Concrete Mixers.*—The Southend-on-Sea Town Council has received the sanction of the Ministry of Health for a loan of £2,884 for the purchase of concrete mixing and tarmacadam plant.

South Shields.—*Sewage Works.*—The Ministry of Health has granted the application of the South Shields Corporation for sanction to borrow £30,000 for sewage disposal works.

Stowmarket.—*Water Works.*—The Ministry of Health has sanctioned the application of the Stowmarket Urban District Council to borrow £12,000 for waterworks extensions.

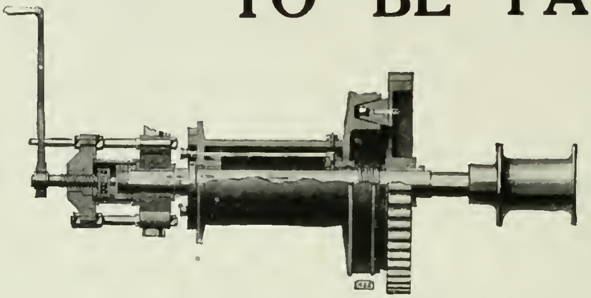
Thornely.—*Water Supply.*—The Ministry of Health has held an inquiry into the application of the Easington Rural District Council for sanction to borrow £56,000 for water supply works at Thornely.

Tunbridge Wells.—*Waterworks.*—The Tunbridge Wells Town Council has decided to apply for a provisional order to enable it to borrow sums up to a total of £200,000 for waterworks extensions.

Winchcombe.—*Water Supply.*—An inquiry has been held by the Ministry of Health into an application of the Winchcombe Rural District Council for sanction to borrow £10,000 for water supply works.

B.S.P. CHATS
No. 3.

A QUESTION TO BE FACED



A SECTIONAL VIEW OF THE BARREL OF THE "ZENITH" FRICTION WINCH.

Behind all operations involving the raising or hauling of masses, the dominating factor must be FLEXIBILITY OF CONTROL, not only for safety, but for ECONOMY. The use of great mechanical power involves an equally great control of that power. Even in the simple operation of Pile Driving, absolute control is essential to satisfactory results. This is the main principle underlying the design and construction of the " Zenith " Friction Winch—PERFECT CONTROL, and this is only attained by a flexibility of action which is unequalled in any other winch. An examination of the illustration shows how this has been secured in the "ZENITH" WINCH to the highest possible degree. " SO SENSITIVE—A CHILD CAN WORK IT " is no idle slogan, it is a terse summing up, in a few words, of the principle qualities of this winch. This sensitiveness enables the power to be used for just those seconds required to perform the duty ; this means ECONOMY OF POWER, and the instantaneous response to control means EFFICIENCY. Its massive construction, and perfectly balanced design makes the " ZENITH " WINCH the most desirable plant to employ on any service for which a high class winch is essential.

If you are interested in this class of operations, it will amply repay you to send for Bulletin No. 82A and learn all about it.

THE BRITISH STEEL PILING CO.,

DOCK HOUSE,
BILLITER STREET, LONDON, E.C.3.
WORKS: CLAYDON, SUFFOLK.

TENDERS ACCEPTED.

Doncaster.—The tender of Mr. J. Done, of Balby, has been accepted by the Doncaster Rural District Council for the supply of concrete kerbs in connection with the widening of Crow Tree Lane, Ardwick, at £1,540. Other tenders received were : J. Done (stone kerbs), £1,590 ; E. Morley & Sons (Derby), £1,651 ; S. Porter & Sons (Barnby Dun), £1,746 15*s.* ; H. E. Buckley (Bradford), £1,761 ; H. Lister (Arksey), £1,765 7*s.* ; S. E. Cox (Bentley), £1,794 9*s.* ; Percy Trentham, Ltd. (Birmingham), £1,900 ; C. Fletcher (Doncaster), £1,900 16*s.* 4*d.* ; Firth & Whittington, Ltd. (Doncaster), £2,466 16*s.*

Durham.—The Works Committee of the Durham County Council has accepted the following tenders :—10 in. by 8 in. concrete kerb, delivered at Pelaw : Stockton Stone and Concrete Co., 8*s.* 6½*d.* per lineal yard ; 36 in., 42 in., and 48 in. rock concrete tubes : Sharp, Jones & Co., 35*s.*, 49*s.*, and 66*s.* per foot.

Glasgow.—The Glasgow Corporation has accepted the tender of Messrs. Melville, Dundas & Whitson, at £5,000 3*s.* 1*d.*, for the execution of reinforced concrete works in connection with the water tanks at the new Municipal Buildings.

London.—The Coppee Co. (Great Britain), Ltd., has been awarded a contract for the erection of a refuse treatment plant for the Westminster Council, for the sum of £10,490.

Neepsend.—Messrs. K. Holst & Co. have received the contract for the erection of a footbridge over the railway at Neepsend, for the Sheffield Corporation, at £2,130.

Reading.—The Reading Corporation has received the following tenders for the erection of 168 houses on the Shenfield Road Estate : Roberts, Ltd., £112,085 ; Unit Construction Co., £114,047 18*s.* 2*d.* ; Bainbridge & Son, £114,470 10*s.* ; Improved Concrete Construction Co., Ltd., £115,373 ; Arding & Hobbs, Ltd., £122,868 ; E. Organ & Son, £123,282 ; L. E. Johnson & Son, Ltd., £123,300 ; Pattinson & Son, Ltd., £124,256 ; W. Jones & Sons, Ltd., £124,301 ; Billings & Co., Ltd., £125,748 ; Francis Bros., £126,631 ; Adams Housing Syndicate, £128,543 9*s.* 4*d.* ; Trollope & Colls, Ltd., £128,866 ; F. R. Hipperson, £130,613 ; Wheeler Bros., Ltd., £132,849 8*s.* 7*d.* ; Butler Bros., £135,010 16*s.* ; J. Cockerell, £135,532 ; Saunders & Sons, Ltd., £137,218 ; A. Cole, Ltd., £139,440 ; Espley & Co., Ltd., £140,171. The tender of Messrs. Roberts, Ltd., has been recommended for the erection of fifty-two houses.

Stockton-on-Tees.—The Stockton-on-Tees Town Council has provisionally accepted the following contracts for the erection of houses on the Blue Hall Estate, Norton : H. M. Norton, from 30 to 60 pairs of pre-cast reinforced concrete houses, at £794 15*s.* each. F. R. Hipperson, 226 houses on the "Interloc" concrete system, at £725 per house. The tenders have been forwarded to the Housing Commissioner.

Yeovil.—The Yeovil Town Council has received the following tenders for the erection of a reinforced concrete reservoir of 750,000 gallons capacity :—R. G. Spiller & Son (Chard), £4,750 ; Bird & Pippard (Yeovil), £4,877 5*s.* ; N. Buckley (Weymouth), £5,206 2*s.* 10*d.* ; Hybert, Broadhead & Co., Ltd. (Reading), £5,435 ; British Construction Co., £5,713 9*s.* 9*d.* ; G. K. Waghorn (Biggleswade), £5,691 6*s.* 4*d.* ; D. G. Somerville & Co., Ltd. (London), £5,985 ; Walter Jones & Son (London), £6,020 10*s.* 8*d.* ; Unit Construction Co. (London), £6,049 18*s.* 11*d.* ; Lambrick & Co. (Burton-on-Trent), £6,070 5*s.* 9*d.* ; G. Pollard & Co., Ltd (Taunton), £6,600 2*s.* 10*d.* ; F. H. Avent & Co., Ltd. (Swansea), £6,653 17*s.* 7*d.* ; Dunthorn, Ltd. (Glastonbury), £6,935 8*s.* 3*d.* ; Saunders & Sons, Ltd. (Cirencester), £7,087 ; Watkin, Williams & Sons (Cardiff), £7,142 ; J. W. Stewart (London), £7,290 12*s.* 1*d.* ; Fothergill Bros. (Exeter), £7,448 8*s.* 2*d.* ; Unit Reinforcement Construction Co. (Melksham), £7,474 ; W. F. Drew, Ltd. (Stroud), £7,576 ; Moehl & Co. (London), £7,858 9*s.* ; P. Wilson & Co. (Exmouth), £8,000 ; Pullar & Co. (Manchester), £8,446 15*s.* ; H. Pittard & Son (Langport), £9,503 6*s.* The Tender of Messrs. R. G. Spiller & Son has been accepted.

TENDERS INVITED.

Newcastle-on-Tyne.—September 12. For erection of car sheds at South Gosforth, Newcastle-on-Tyne, for the North Eastern Railway Co. Specifications, etc., from Mr. W. H. D. Devey, Secretary to the Company, York.

Yeovil.—September 12. For (1) reinforced concrete linings to four arches at Mudford Viaduct, Yeovil, and (2) street works. Specifications, etc., from County Surveyor's Office, 49, High Street, Weston-super-Mare. Deposit, £1 1*s.* each contract.

Birkenhead.—September 14.—For Construction of Gorsefield Road, for the Birkenhead Corporation. Forms of tender, etc., from Mr. C. Brownridge, Borough Surveyor, Birkenhead. Deposit 10*s.*

Greenwich.—September 15. For paving of Horn Lane, Greenwich, for the Greenwich Borough Council. Specifications, etc., from the Borough Surveyor, Town Hall, Greenwich, S.E. 1.

Farnham.—September 19.—For Construction of sewers & manholes at Hale Ward for the Farnham Urban District Council. Forms of tender, etc., from the Engineer and Surveyor to the Council, South Street, Farnham. Deposit, £2 2*s.*

Johannesburg.—September 23. Supply and erection of filter installation of 5½ million gallons per day capacity, at the Vereeniging Main Pumping Station. Specifications, etc., may be seen at the Inquiry Room, Department of Overseas Trade, 35, Old Queen Street, S.W. 1.

Wallasey.—October 15. For construction of floating goods landing stage, 320 ft. by 80 ft. for the Wallasey Town Council. Specifications, etc., from Messrs. Wilton & Bell, engineers, 1, Crosshall Street, Liverpool. Deposit, £5 5*s.*

Uruguay.—November 17. For construction of water and drainage works at San José. Further particulars from the Department of Overseas Trade, 35, Old Queen Street, Westminster, S.W.

NEW COMPANIES REGISTERED.

Amalgamated Housing Industries, Ltd. (175,241). Registered June 17. To enter into an agreement with the Standardised Construction Development Co., Ltd., and carry on the business of builders and contractors. Nominal capital, £650,000 in 300,000 cumulative participating preference shares of £1 each, and 350,000 £1 ordinary shares. Directors to be appointed by subscribers. Qualification of Directors, £500 ; remuneration, £250 each (Chairman, £400, Vice-chairman, £300). Sub-

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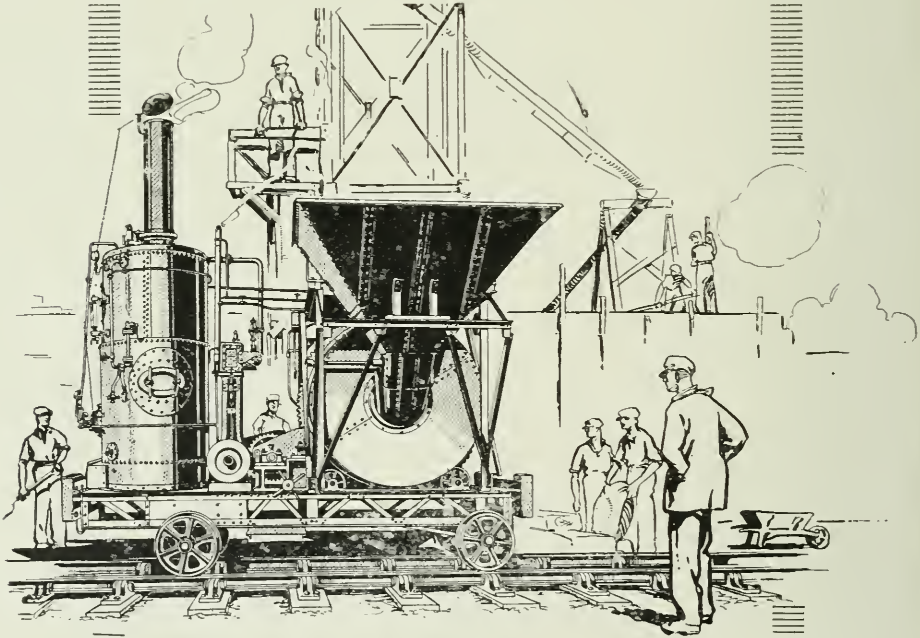
May we send you catalogue M.D. 103, which explains the Victoria Concrete Mixer in fullest detail?



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scribers: W. J. G. Coman, 23, Elsie Road, Dulwich, S.E.; W. H. Walford, 10, Forest Road, Leytonstone, E.; and five others.

Barnes, Chaplin & Co., Ltd. (175,345). Registered June 23. Nominal capital, £20,000 in 20,000 £1 shares. Directors: R. P. Barnes, 19, Wordsworth Road, Cardiff, and W. Chaplin, 152, Marlborough Road, Cardiff. Remuneration of Directors to be voted by Company.

Lunstone Concrete Co., Ltd. (175,561). Registered July 5. De la Warr Road, Bexhill, Sussex. Manufacturers of bricks, concrete, and artificial stone. Nominal capital £5,000, in 5,000 £1 shares. Managing Director: T. Prentice, 8, Victoria Terrace, Downhill, Glasgow; Directors: G. T. Jennings, 4, Linden Road, Bexhill-on-Sea; G. Lomer, Windsor Cottage, Cooden, Herts.; and E. H. Prior, 22, Cosbycote Avenue, Herne Hill, London, S.E. Qualification of Directors, £100; remuneration, £10 each.

Stanford-le-Hope Sand Co., Ltd. (175,712). Registered July 13. Abbot's Hall, Stanford-le-Hope. To work sand, gravel, ballast, etc., pits. Nominal capital £5,000, in 5,000 £1 ordinary shares. Directors: A. G. Whitlock, 9, Drapery Gardens, Northampton; and A. C. Marriott, Abbots Hall, Stanford-le-Hope. Qualification of Directors, £250; remuneration to be voted by Company.

British Empire Lapistone Syndicate, Ltd. (175,849). Registered July 21, 440, Fulham Road, S.W.6. Manufacturers of all kinds of stone and cement. Nominal capital £15,000 in 13,000 £1 10 per cent. cumulative participating preference shares, and 40,000 1s. ordinary shares. Directors to be appointed by subscribers; qualification, 50 shares; remuneration to be voted by Company.

The Longford & Midland Concrete Co., Ltd. (175,925). Registered July 25. Dealers in, and manufacturers of, concrete. Nominal capital £2,000 in 2,000 £1 shares. Directors: A. G. Johnson, Station Road, Longford; T. F. Bolton, 286, Foleshill Road, Coventry; and D. E. Pearson, 286, Foleshill Road, Coventry. Qualification of Directors, one share; remuneration to be voted by Company.

Monolithic Structures, Ltd. (176,248). Registered August 12. Designers and constructors of concrete and reinforced concrete buildings. Nominal capital £2,000 in 200 £1 shares. Directors: R. G. Clarry, "Penalt," Sketty, Swansea; and T. R. Grigson, 2, Gwydr Crescent, Swansea. Qualification of Directors, £50; remuneration to be voted by Company.

RECENT PATENT APPLICATIONS.

121,585.—J. P. B. Bessonneau & C. H. Besnard: Concrete structures.

138,922.—R. V. Mattison: Manufacture of asbestos-cement sheeting.

139,204.—Bonnett Aine et Fils: Concrete block-making machine.

142,121.—P. B. M. Caron: Concrete and reinforced concrete pipes.

146,252.—Adams Pond Co.: Construction of concrete floors and slabs.

150,988.—The Ambursen Engineering Co.: Mould for the construction of floors, walls and ceilings.

163,074.—B. Bardley: Reinforced Concrete pipes.

163,346.—J. F. Cowper: Fireproof building construction.

163,400.—J. G. Davis: Construction of floors and ceilings.

163,441.—H. I. Hooper: Concrete block-making machines.

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163,471.—F. E. Walker and C. H. Hill: Reinforcement for concrete structures.

163,569.—R. Milner and T. Robinson: Manufacture of building blocks from blast-furnace slag.

163,572.—Concrete blocks and block-making machine.

163,731.—D. Dale: Concrete for the manufacture of building blocks, slabs, etc.

163,746.—H. Alexander: Building sheets, blocks, tiles, etc.

163,783.—G. Calver: Buildings constructed with concrete blocks and slabs.

163,827.—E. C. Dittmar: Method of floor finishing.

163,849.—P. W. Griffin: Concrete buildings, and method of moulding concrete walls.

164,109.—J. Abbott and S. P. Shaw: Reinforced concrete walls and partitions.

164,125.—M. M. Smith: Pre-cast blocks, beams, piers, etc.

164,233.—A. S. Adams: Cement and concrete building blocks and slabs.

164,465.—E. and A. P. Hurden and S. E. Beeson: Walls and partitions.

164,518.—M. S. Moore and B. L. Jenkins: Machine for moulding building blocks.

164,666.—C. F. Curtis: Cementitious composition for flooring, etc.

164,792.—A. J. Bohringer, W. Digby & W. G. Ramsey: Concrete blocks and bricks.

164,947.—Bell Bros., Ltd., and M. R. Kirby; Concrete building construction.

165,120.—W. Bagguley & R. Hickton: Building blocks and bricks.

165,266.—K. Albert: Manufacture of building blocks and bricks, and the construction of buildings.

165,466.—W. W. Clarke: Concrete houses built *in situ*.

165,559.—J. Thewlis: Concrete block making machine.

165,884.—W. Marriott: Concrete posts.

165,887.—J. Johnston: Construction of concrete buildings.

165,911.—P. B. Jagger: Mould for concrete.

165,962.—Concrete Dwellings, Ltd., and H. Edon-Brown: Moulds for the manufacture of hollow concrete buildings.

165,972.—P. S. King: Concrete building blocks.

166,002.—J. B. Harvey: Concrete mixer.

166,012.—Bell Bros., Ltd., and M. R. Kirby Concrete buildings.

166,087.—R. Pattinson: Concrete buildings.

166,172.—R. H. Annison: Reinforced concrete buildings.

166,299.—W. Bijvoet and G. Delton: Cores for use in moulding concrete.

166,338.—M. M. Smith: Apparatus for use in concrete wall construction.

166,360.—P. S. King: Supports for concrete floors in course of construction.

166,402.—W. E. Clifton and G. S. Ewart: Concrete slab building construction.

166,424.—A. S. Horton: Construction of concrete walls.

166,457.—D. M. Newton: Concrete piling.

ERRATUM.

Colwood Road.—When showing this illustration in our frontispiece of the July issue, the road was inadvertently stated to be in Vancouver. The correct title should have read:—"Colwood Road, Island Highway, near Victoria, Vancouver Island."

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Surveyor.—"Road engineers will warmly welcome the book on Concrete Roads. It is very well illustrated with photographs of the roads. The book will be found extremely useful by all road engineers, and make a valuable addition to their libraries."

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 10. LONDON, OCTOBER, 1921

EDITORIAL NOTES.

BRITISH EMPIRE EXHIBITION.

To England belongs the honour of holding the first large exhibition which was organised on comprehensive lines, endeavouring to bring together exhibits of various kinds from different countries. It may be said that the first modern exhibition was arranged in 1756 by the Society of Arts, at which prizes were offered for improvements in the manufacture of textiles and ceramics, but it was thanks to the indefatigable labours of the Prince Consort that the first great exhibition was held in Hyde Park in 1851, in the now famous Crystal Palace, designed by Joseph Paxton—subsequently knighted—now re-established at Sydenham.

The idea being essentially a good one, since it promoted intercourse amongst nations and stimulated trade, it was naturally soon taken up by other countries. In France three great international exhibitions were held: in 1878, in 1889 and in 1900. The last achieved great fame, and many buildings were specially erected which survive to this day, such as the Petit Palais, designed by Girault, and the Grand Palais, designed by Deglane, Louret and Thomas. America, too, was not behind in such enterprises, and in 1893 the great World's Fair at Chicago was opened. The buildings at this exhibition were the prototype for most subsequent exhibitions, and many of them were the work of famous architects; McKim and Burnham, Sullivan and Post designed a Horticultural Hall, a Woman's Palace, a Machinery Hall, and an Art Palace.

The exhibition had, in fact, entered upon a new phase since the great gathering of 1851, comprising now a collection of buildings rather than a single vast enclosure, and combining the various aspects of civilisation: science, commerce, the arts, the crafts, sport, recreation, all in juxtaposition, so that the place becomes a centre for the exchange of thought and for the assimilation of ideas, for the recreation of the body and for the expansion of the mind. It thus affords a great opportunity for a magnificent architectural achievement.

The British Empire Exhibition, which it is proposed to hold in 1923, aims at bringing together the resources of the Empire, with a view to their better exploitation, and furthermore, at enlightening the various countries of the Empire as to each other's activities, both social and industrial, both artistic and scientific. It is, in fact, to be a vast Imperial clearing house. And as such demands that its buildings, their grouping, their equipment and their surroundings shall be worthy of this fine purpose.

A site has been selected at Wembley Park, which possesses all the qualities making for success, for it combines accessibility with rare natural beauty. A tentative layout plan has been prepared by the official architects, Messrs. Simpson & Ayrton. This shows a sports arena, buildings for British and Dominion exhibits, restaurants, an open-air theatre, a band stand, and two lakes. The layout is arranged on a north and south axis, which is terminated at the south by the sports arena and at the north by a large lake, which is more than four acres in extent. In the centre will be gardens, and it is to be hoped that provision will be made for open-air restaurants. The buildings, we are told, " will be of the most modern construction, and of a style specially suited for the purpose in view ; they will be of a permanent character." Of the actual design of the buildings nothing is as yet known, except that the sports arena is to be sufficiently large to accommodate 125,000 spectators, and that it will possess " some striking architectural features reminiscent, in some degree, of Greek and Roman Stadia." To the unprejudiced mind there can be no doubt that reinforced concrete is the most suitable material for constructing both this and the other buildings. Let us consider the requirements : permanency, vast open and unobstructed floor spaces, light and air, beauty and dignity. One by one other materials may be relegated as being less suitable. Brick, which possesses beauty of colour and texture, lacks grandeur and is, of course, constructionally absolutely incapable of fulfilling the required conditions. Masonry introduces difficulties of thrust and counterthrust, requires huge abutments, and fails in other ways. Steelwork requires a covering of stone, and is, at best, a poor collaboration of architect and engineer. Reinforced concrete, however, fulfils all the requirements, moreover, since it is plastic, strong in both tension and compression, capable of taking any form without difficulty ; a material which, if handled in a bold imaginative way, is capable of suggesting its own beautiful and appropriate decoration, it, at once, becomes the right medium for the architect. It is expressive of the age, and such an exhibition must be free from anachronistic displays of pedantic scholarship.

We sincerely hope that the architects may set an example to their more cautious brethren, and seize this grand opportunity that has been afforded them, and, freeing their minds from the sugar-icing architecture that has characterised past efforts at exhibition building, and from the obsession of " classical forms," produce a collection of buildings arranged on a coherent plan that shall be worthy of their great Imperial purpose. We are not demanding vulgarity or novelty, but we do think that a comparatively new material has its own appropriate treatment. This the skilful architect must find and exploit ; he must exploit it, too, to express the sentiments and aspirations of a great empire. This is no easy task, but fortunately there is time for mature consideration of the problem in all its manifold aspects. English architects generally are not well informed as to the proper surface treatment of concrete, and are unfamiliar with the beautiful results of both colour and texture that can be obtained. Here is an opportunity for showing what can be done.

Wasting great opportunities, especially in matters connected with architecture, is an unfortunate national characteristic. Let this, at least, be a noble exception.

THE FIRE RESISTANCE OF CONCRETE.

An opportunity for observing the behaviour of concrete under severe fire occurred last year in connection with two conflagrations which took place within six months of one another (May and October) at a warehouse in Galveston, which was used for the storage of sisal, a central American hemp. The warehouse, which was of the most modern flat slab type of construction, was a two-storey building, divided into four sections and situated on the Galveston Wharf Co.'s Pier No. 41.

We have not very full particulars before us regarding the first conflagration, but on that occasion the section of the warehouse where the fire was localised suffered almost complete demolition ; the fire took place on the upper storey and the floor entirely collapsed.

The reasons given for this are, that the floor was carrying nearly its maximum load, and with the added weight of tremendous volumes of water and the intense heat, these were enough to cause the floor to collapse, dropping the fire to the lower deck and carrying the roof and side walls of that section of the pier with it.

In the case of the second fire the structural damage was confined to extensive spalling at construction joints and to floor cracking.

Except that the fires occurred, in the first case in the upper storey and in the second instance on the lower deck, the local conditions in both instances appear to have been the same. Both fires occurred in stores filled with bales of sisal, at about the same hour of the day, and they were of nearly the same duration.

In the case of the conflagration in October we have before us two reports by engineers who witnessed the fire, and one of these reports reveals some of the most interesting facts on the behaviour of construction joints.

Quoting from the engineer's report, reproduced in *Engineering News Record*, the writer there says : " Of especial interest was the effect of the fire on the construction joints of all slabs where these joints occur. . . . These joints, where pouring operation was discontinued until the next day, or at a later time during erection, were not especially prepared by roughing the surfaces or by any other apparent means, to insure or contribute to the bonding of new concrete to the old. Examination disclosed very smooth surfaces and the absence of any indication of bond. The joints proved to be the weakest part of the entire construction in offering resistance to the effects of intense heat, and have rendered the question of repairing a difficult one. . . ." The writer points to the absolute necessity of far greater care being exercised when bonding old and new concrete surfaces and goes on to say : " This fire demonstrates beyond doubt the surprising extent of weakness developed by construction joints during exposure to great extent."

Another finding in connection with these conflagrations is one to which we have previously called attention in these pages in connection with other large fires, namely the great value of flat surfaces without sharp corners, if the greatest protection against fire is to be attained, in reinforced concrete structures.

In the second report the writer gives particulars of his observations on the behaviour of the concrete floor in the section attacked by fire. After the fire had been burning for one hour and ten minutes the intense heat of the concrete floor was noticed, and an examination showed that there were large cracks running transversely of the floor. As the fire progressed the heat of the floor increased and more cracks appeared, as well as others running longitudinally of the building, and those first observed seemed to have widened. The floor was carrying a load of about one-quarter of the maximum allowable dead load, stated to be 375 lb. per sq. ft., but in spite of this, when the fire was declared under control, the floor was still intact.

Observations made since the fire was extinguished and the concrete had cooled show, that although the cracks naturally remain, no sinking of the floor has taken place and there is no apparent weakening. Where the floor blistered and rose it has receded to approximately its original level, but the finish coat of cement is of course badly broken and the rough concrete has become exposed.

BEAUTY AND ECONOMICAL BUILDING.

THE architectural result that can be achieved without consciously striving after the beautiful is admirably demonstrated in the view we give on p. 638 of the interior of the Cross Hill covered reservoir, built in connection with the Alwen water supply of the Birkenhead Corporation, from the design of Sir Alexander Binnie, Son & Deacon. In a covered reservoir, the interior of which is rarely seen after it has been put in use, and which is never seen by the general public, there is no reason why its æsthetic appearance should be considered at all; the main objects to be achieved are a structure that will efficiently perform what is required of it, and economy in cost. After considering various methods of construction the engineers decided that an entirely new system of concrete construction would be the most economical while at the same time giving the necessary strength, and so well have their anticipations been realised that the Cross Hill reservoir is claimed to be the cheapest ever built in this country. From this basis of economical building a most remarkable effect has been obtained. There has been no seeking for effect and no superfluous material has been used for decoration. It is an excellent illustration of the axiom that artistic satisfaction naturally follows an honest and direct expression and constructive purpose.

CONCRETE TANKS FOR FUEL OIL STORAGE.

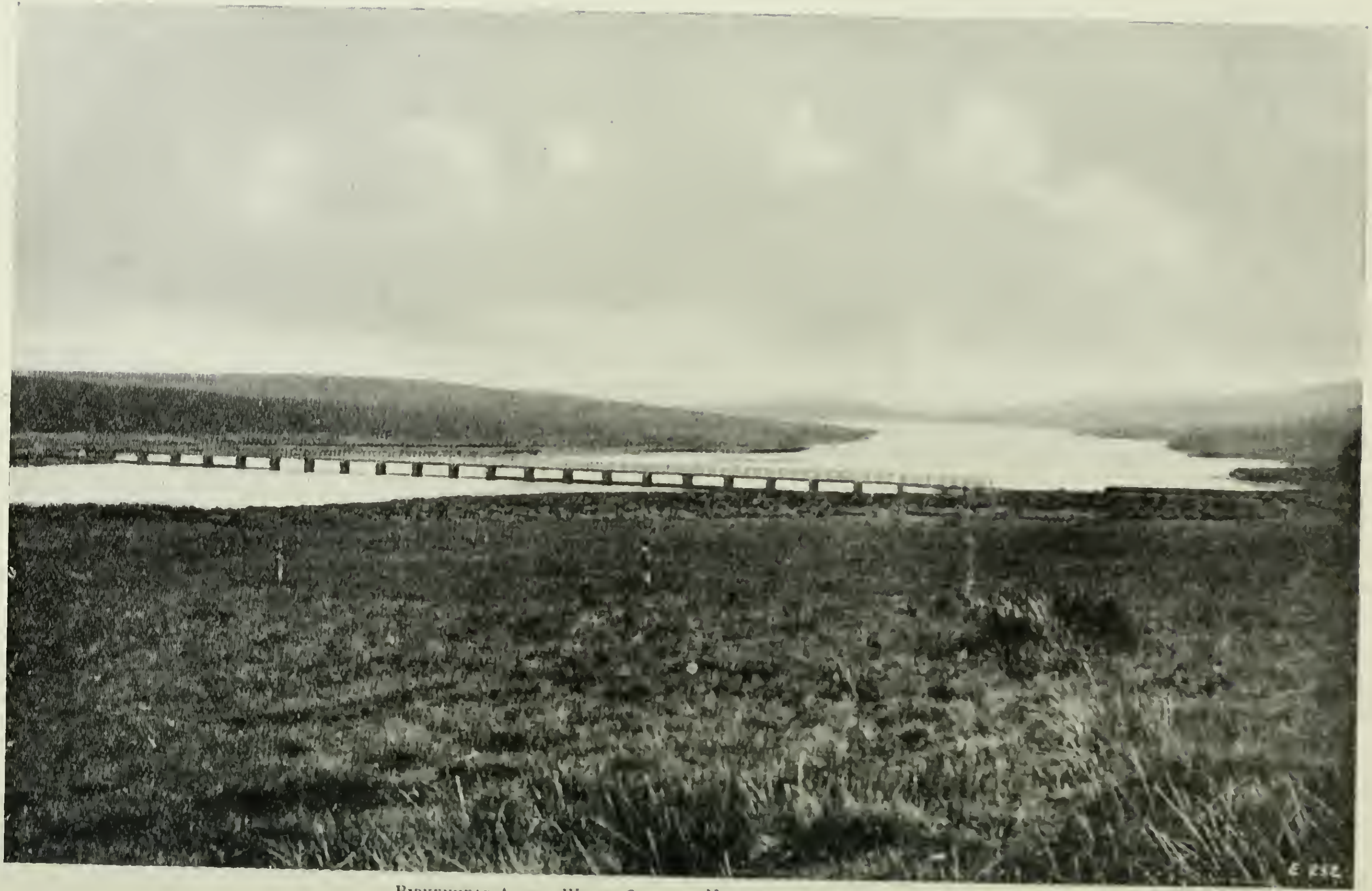
IT is interesting to note that at the present time there are no fewer than 481 concrete tanks for fuel oil storage in America and Canada, representing 882,494,600 gallons capacity.

The practicability of storing fuel oil in concrete tanks there, has been definitely proved by experience extending over a period of seventeen years. The oil so stored varies from Mexican crude to kerosene. Certain refiners in Kansas and Oklahoma are even storing gasoline in concrete tanks. In view of the increasing use of fuel oil in the industrial world the adaptability of concrete for oil tanks undoubtedly has a special value.

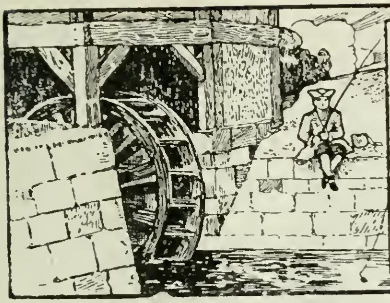
NORTH CIRCULAR ROAD, WILLESDEN.

IN further reference to an article which appeared in our issue of September on the above road, we publish a letter this month, on page 684, from Mr. F. Wilkinson, M.Inst.C.E., Engineer to the Willesden District Council, regarding the consistency and homogeneity of the concrete used in relation to the Walker-Weston Reinforcement employed on this road.

632w.



Birkenhead-Alwen Water Supply: Nant Heilyn Weir (*see p.* 633).



THE BIRKENHEAD-ALWEN WATER SUPPLY.

On August 15, the ceremony of turning on the new water supply from the river Alwen, Denbighshire, to the town of Birkenhead was performed by Alderman Henry Bloor, Chairman of the Water Committee of the Birkenhead Corporation. This work, which is one of the largest undertakings of its kind carried out during recent years in this country, and embodies many novel and interesting constructional features, was commenced in 1911, but the war considerably hindered its completion. It was on the advice of the late G. F. Deacon that the Corporation decided to obtain a supply of water from North Wales, and on his death in 1909 the preparation of the designs and the supervision of the construction of the work were entrusted to the firm of Sir Alexander Binnie, Son & Deacon, consulting engineers, of Buckingham Gate, Westminster, to whose courtesy we are indebted for the photographs reproduced in this issue and for the particulars we are able to give.

The reservoir formed is about three miles in length with an average width of one-fifth mile and contains over 3,000,000,000 gallons of water. The formation of this reservoir necessitated the removal of over 1,000,000 cubic yards of peat, and a means of crossing is provided by a concrete weir, known as the Nant Heilyn weir. A building containing ten batteries of mechanical filters is erected below the dam, and from this point to Birkenhead, a distance of 42 miles, the water is conveyed by an aqueduct of cast-iron pipes and four tunnels. At two points on the pipe line balancing tanks have been built, and at Cross Hill there is a covered service reservoir with a capacity of 30,000,000 gallons. The major part of the pipe line was carried out by Messrs. John Cochrane & Sons, Ltd., while the reservoir, the Alwen Dam, the Cross Hill service reservoir and a portion of the pipe line were constructed by Sir Robert McAlpine & Sons. Whilst the contract as a whole has many points of interest, the bulk of the concrete work is in the Cross Hill covered service reservoir, the Alwen Dam, and the Nant Heilyn weir, and it is to these three works that the following notes are confined.

THE CROSS HILL COVERED SERVICE RESERVOIR.

This reservoir (a description of which in its earlier stages, with some illustrations, was given in our issue for August, 1914) is of unique design, and is probably the most economical covered reservoir ever constructed. The contract was let in 1913 for the sum of £79,000, or about £2,800 per million gallons of storage; comparing with an average cost of £5,000 per million gallons for several covered service reservoirs built in connection with the London water supply. It covers an area of 3·6 acres, and holds 30,000,000 gallons. The total depth is 32 ft., of which 5 ft. is below ground level. The roof consists of 217 concrete domes, each 30 ft. in diameter, supported on 432 pillars built of concrete blocks, hexagonal on plan. The side walls are designed to support the embankment when the reservoir is empty and to transmit the thrust to the embankment when the reservoir is full. They consist of a series of horizontal arches which transmit the pressure of the embankment when the reservoir is full to vertical plate girders, and thence to the floor and roof. The reservoir is hexagonal

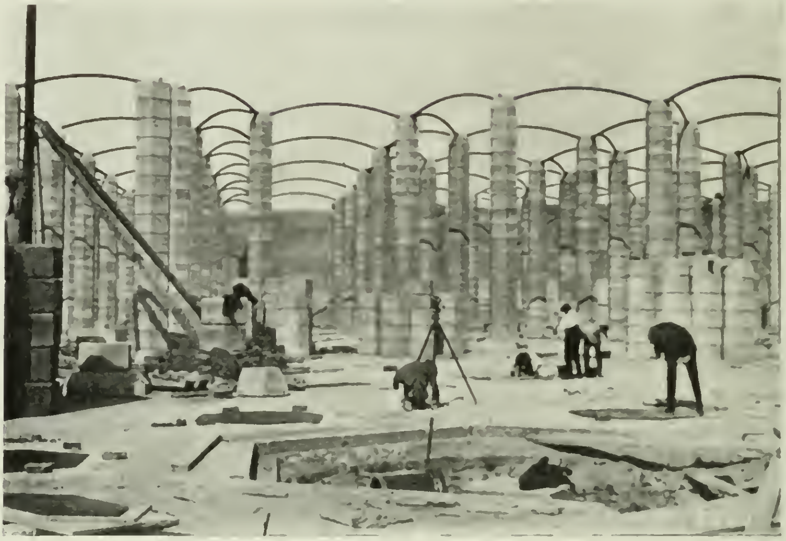


FIG. 1. CROSS HILL RESERVOIR, SHOWING COLUMNS WITH REINFORCEMENT OF GROINS IN POSITION.

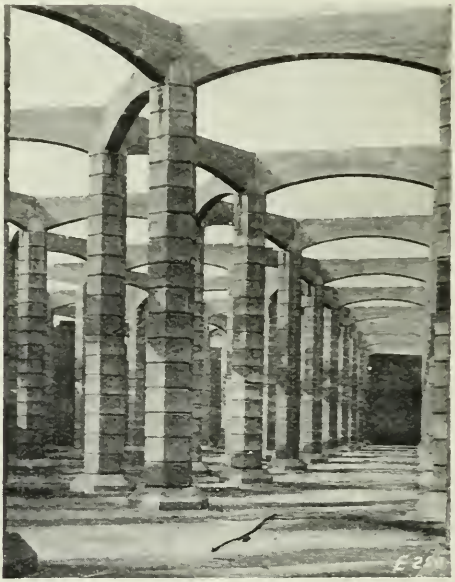


FIG. 2. CROSS HILL RESERVOIR, SHOWING GROINS IN POSITION.

in shape, each side of which has eight arches with a span of 30 ft. and a radius of 27 ft. 6¼ in. and a span and radius of 17 ft. 4½ in. at the angles.

Concrete.—The concrete used was divided into two classes :—No. 1, in which the broken stone did not exceed 2 in. ; and No. 2, in which the maximum size of the broken stone was ½ in. For concrete No. 1 white and pink sandstone, obtained locally, was used, while for concrete No. 2 limestone chippings, obtained from the lead mines in Wales, were used. The following proportions were adopted :—Concrete No. 1 : 1 part of cement to 2·41 parts of sand and 4·16 parts of stone ; concrete No. 2 : 1 part of cement to 1·93 parts of sand and 3·86 parts of stone. Tests on beams of No. 2 concrete, 3 ft. by 6 in. by 4 in., laid on supports 2 ft. apart and loaded at the centre until they broke, showed that they failed when the stress was 251 lb. per sq. in. at 28 days and 516 lb. per sq. in. at four months. Crushing tests on the two kinds of concrete gave results somewhat different from what was expected, as it was thought the limestone chippings used in the No. 2 mix would bear a greater crushing stress. However, the tests showed that cubes of No. 1 concrete made in 9 in. moulds had a crushing strength of 205 tons per sq. in. at 28 days and 253 tons at one year, while cubes of No. 2 concrete made in 6 in. moulds had a strength of 160 tons at 28 days and 230 tons at one year.

Floor.—The floor of the reservoir is generally 12 in. thick, of No. 1 concrete, on a foundation of hard sand. Below each pillar the floor is 2 ft. thick over a hexagonal plan 8 ft. in width, the extra 12 in. of thickness being splayed at an angle of 45 degrees to the floor level. The foundation under the side walls is carried down 2 ft. 3 in. below floor-level, and under the plate girders to 3 ft. 2 in. below floor-level. To prevent the percolation of water through temperature cracks which might develop in the floor, the whole of the floor area is covered with a layer of asphalte ¾ in. thick, which is carried under the pillars and side walls so as to be continuous. Seysel asphalte, in two ⅜ in. layers, was used. Drainage is secured by giving the floor a fall of 6 in. from the centre to circumferential dished channels having a fall of 12 in. to the inlet well from the opposite corner of the tank.

Pillars.—The pillars which support the roof, 432 in number, are hexagonal in shape, built up of No. 2 concrete blocks (*Figs.* 1 and 2). The blocks are 18 in. deep and 3 ft. across between parallel sides, and 16 are used for each column. As the blocks were made in wooden moulds, and it was therefore impossible to ensure that they would be absolutely exact in size and shape, the top and bottom edges are chamfered in order to avoid any irregularity being noticeable. The pedestals of the pillars are hexagonal in shape, 15 in. thick and 4 ft. 6 in. between parallel sides, the extra 9 in. on each of the six sides being chamfered to the floor-level at an angle of 45 degrees. Each pillar is topped with a moulded concrete cap 18 in. in depth, splayed at the top so as to form an abutment for the groins at right angles to the neutral axis where it meets the column (*Fig.* 1). The blocks in each pillar are dowelled together by a Portland cement mortar filling, poured through a continuous vertical circular hole, 6 in. in diameter, which is formed by the insertion of a central core in each block during the process of moulding, as shown in *Fig.* 11. The caps of the columns are covered with a steel gusset-piece to which the reinforcement of the groins (*Fig.* 1) is attached. The gusset-pieces are secured to the columns by a steel rod 1½ in. in diameter and 4 ft. 6 in. long, which is passed down and grouted into the central hole.

Groins to Domes.—There is no tension on the groins which support the domes, and the reinforcement, consisting of rolled steel joists, 5 ft. by 3 in. by 11 lb. (shown in *Fig.* 1), bolted to the gussets at the top of the columns, was primarily introduced to secure the tops of the columns and prevent cross strains on them during construction. They also strengthened the groin to take the load of the green concrete of the dome during construction. The groins are arched to a radius of 20 ft. 4 in., and are composed of No. 2 concrete. It was stipulated that the whole of the pillars should be tied together with the reinforcement before the concreting of the groins was commenced ; the

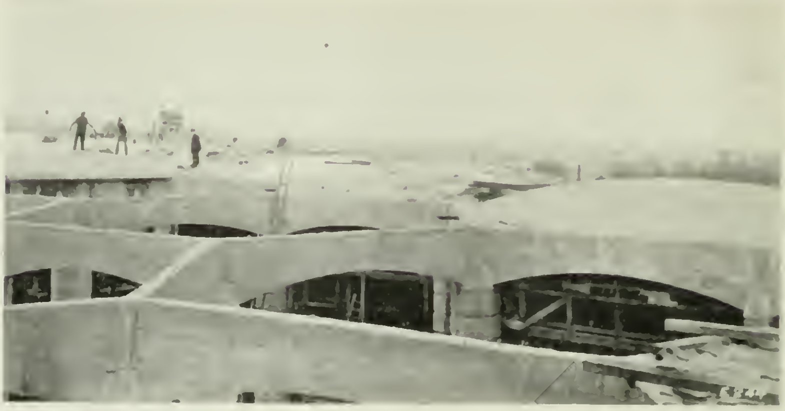


Fig. 3. Cross Hill Reservoir, showing Construction of Domes.

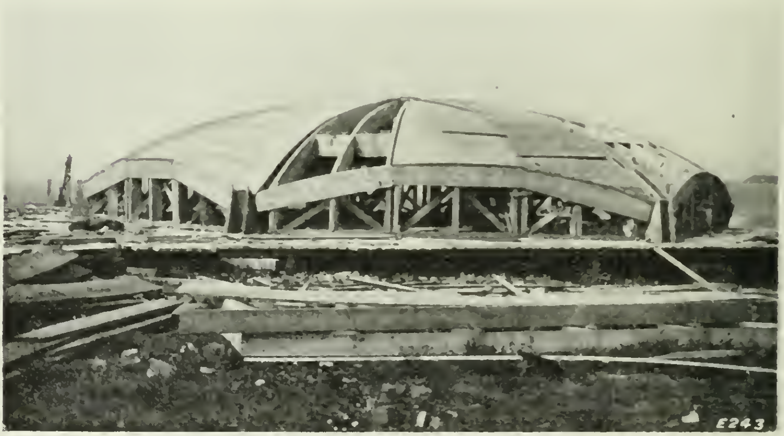


Fig. 4. Cross Hill Reservoir, Centering to Domes

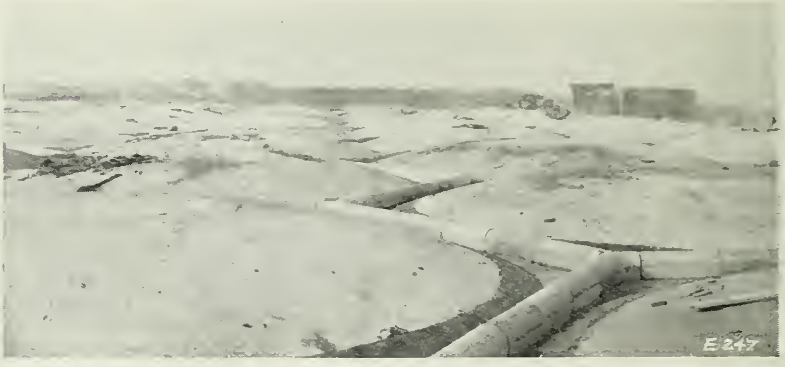


Fig. 5 Cross Hill Reservoir, showing Roof Drainage.

concreting, was, however, commenced before the whole of the reinforcement was in place, and it was found that when the concrete approached the place where the steelwork had been omitted the pillars moved slightly and that horizontal cracks appeared between the blocks, thus showing the advisability of the stipulation. The whole of the groins were completed before the domes were put in place.

Domes.—The domes spring from the groins resting on the tops of the pillars, and the span from centre to centre of opposite parallel lines of the hexagonal plan is 30 ft. The domes are of No. 2 concrete. The following points determined the design :

(1) The minimum thickness of the concrete to be 6 in.

(2) The line of thrust when the dome was completed and loaded was to pass through the middle third of thickness of concrete, so that there would be no tension.

(3) The extrados of the dome was to be formed so that double shuttering would not be required at the springing ; that is, the maximum inclination of the surface to the horizontal was to be such that green concrete would stand at that angle.

The second condition could not be fully met, as the loading varied according to whether the sand covering the tank was wet or dry, but the actual tension is small under either condition.

The radius of the intrados of the dome varies from 50 ft. to 17 ft. as the springing is approached, and the thickness of the concrete varies from 6 in. at the centre of the dome to 13 in. at the centre of the groins.

Each dome was completed at one operation so as to avoid planes of weakness, and it was specified that fourteen days should elapse before the centering was struck. The centering for each dome consisted of 19 timber segments, 18 dome sections, and a key-piece. This centering was supported on six scaffolds, triangular in plan, securely braced and mounted on wheels. One of these scaffolds was placed between each pair of pillars supporting the dome, the apices meeting at the centre of the dome. When wheeled into position they were blocked up from the floor and carefully levelled, the centering resting on the platform thus formed. After the expiration of fourteen days the centering was dismantled by first taking away the key-piece, after which the segmental pieces were removed, and lastly the triangular scaffolds were wheeled away and re-erected under the next dome to be constructed. The construction of the domes is shown in *Figs.* 3 and 4.

As it was anticipated that contraction cracks would occur at the junction of the domes with the groins no attempt was made to secure adhesion between the dome and the groins ; this anticipation was fulfilled, as temperature cracks did appear along these lines, only minute surface cracks being visible in the domes.

The valleys between the domes are levelled up from the centre to the sides of the top of the reservoir in order to provide a fall for drainage, and asphalte ¾ in. thick is laid along the lines of the juncture of the domes and the groins to prevent surface water from percolating through the temperature cracks. To facilitate the passage of the drainage water, special concrete drains are laid throughout the zig-zag valleys between the domes and carry the water to down pipes at the sides of the reservoir. The sections of these drains are butt-jointed and provided with notches to facilitate the entry of the water. Over the pillars a moulded three-branch piece is provided. The roof drainage system is shown in *Fig.* 5.

For test purposes, a section of a dome, 2 ft. wide, was constructed, the sides being parallel sections at right angles to the springing and the centre corresponding to the centre of the dome. This test piece formed an arch 2 ft. wide having the same span, the same rise, and the same thickness as the dome at corresponding distances from the centre, but owing to the absence of lateral support it was, of course, weaker than the actual dome. When 19 weeks old the strip was loaded with sand to 5½ tons, distributed symmetrically but not uniformly on the arch ; this was the actual loading to which it would be subjected in practice. One half of the arch (from the springing to the centre)

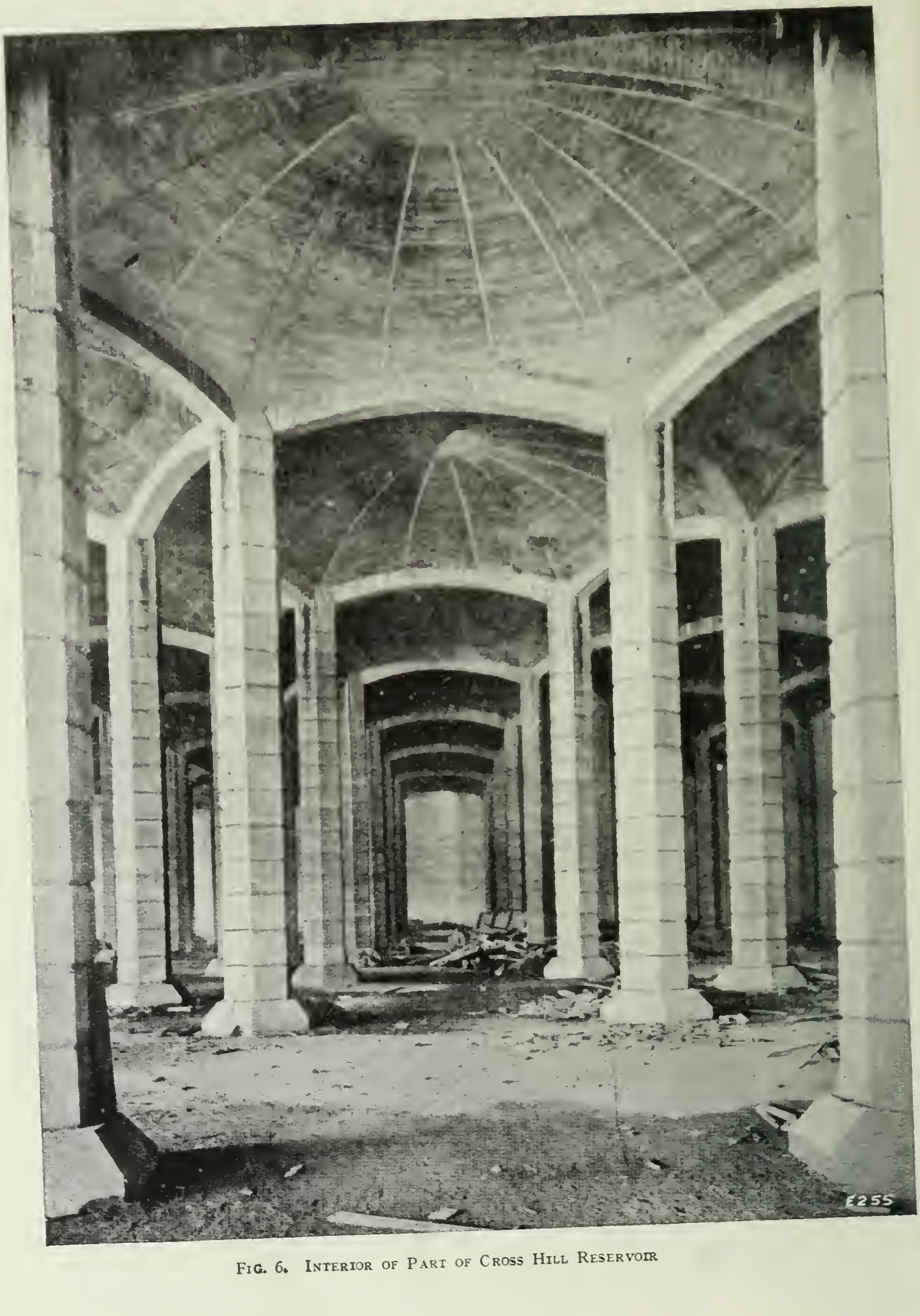


FIG. 6. INTERIOR OF PART OF CROSS HILL RESERVOIR

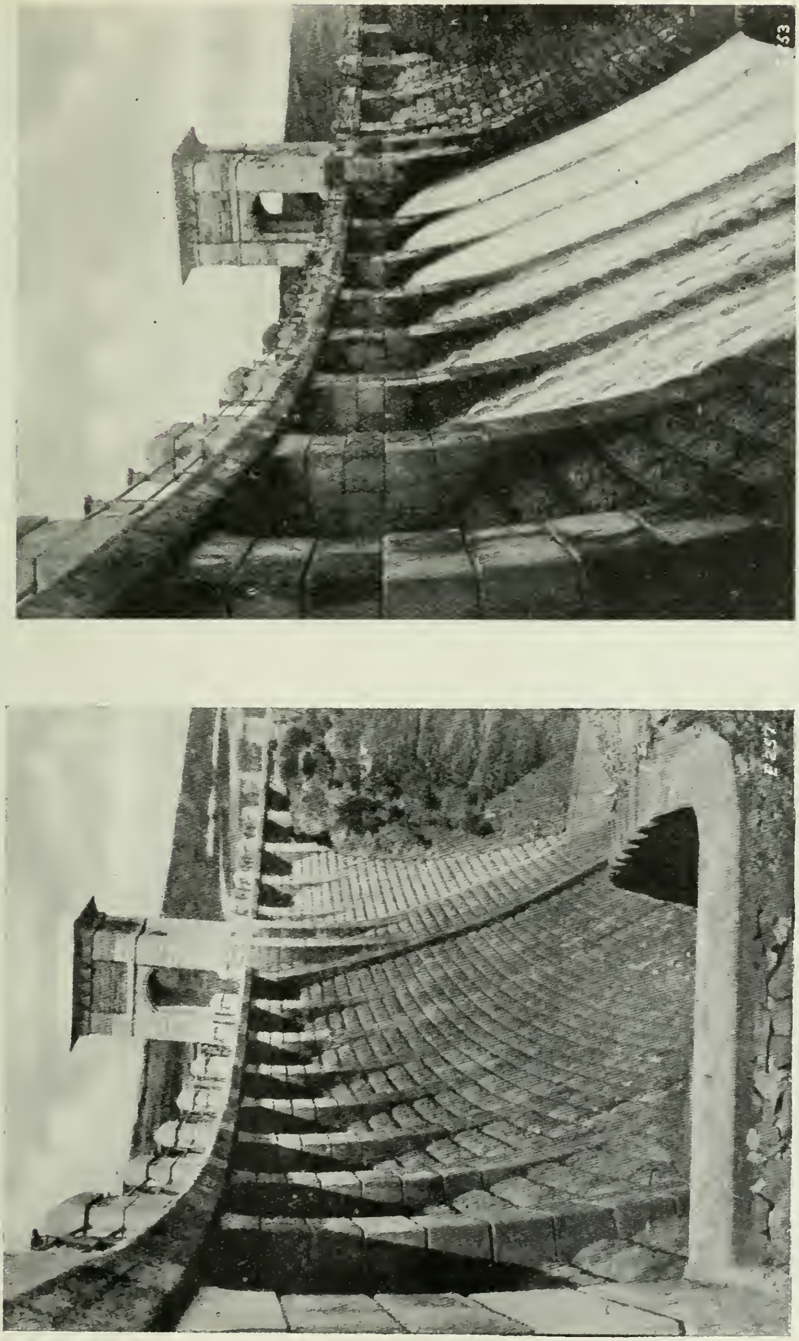


Fig. 7. The Alwen Dam: Downstream Face.

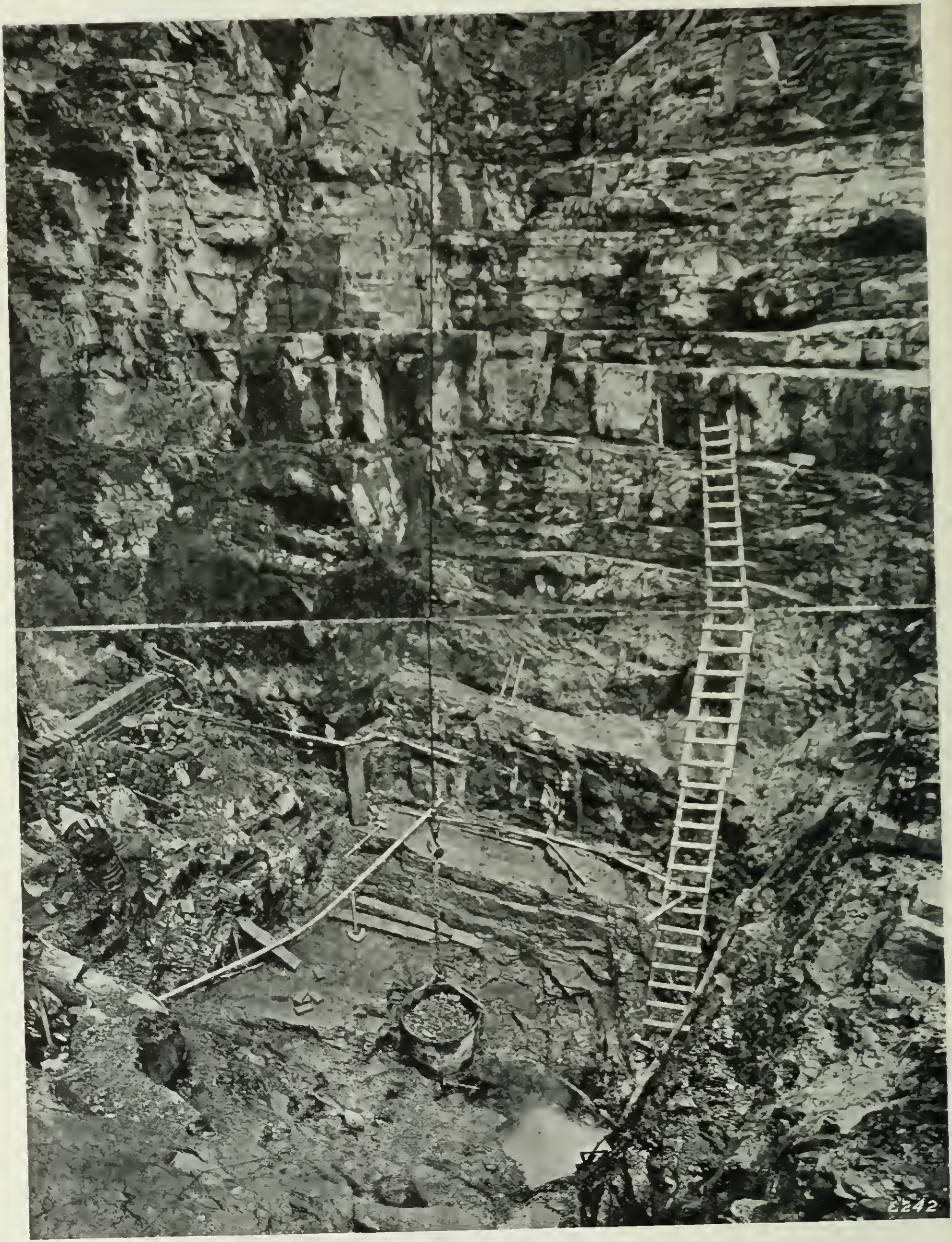
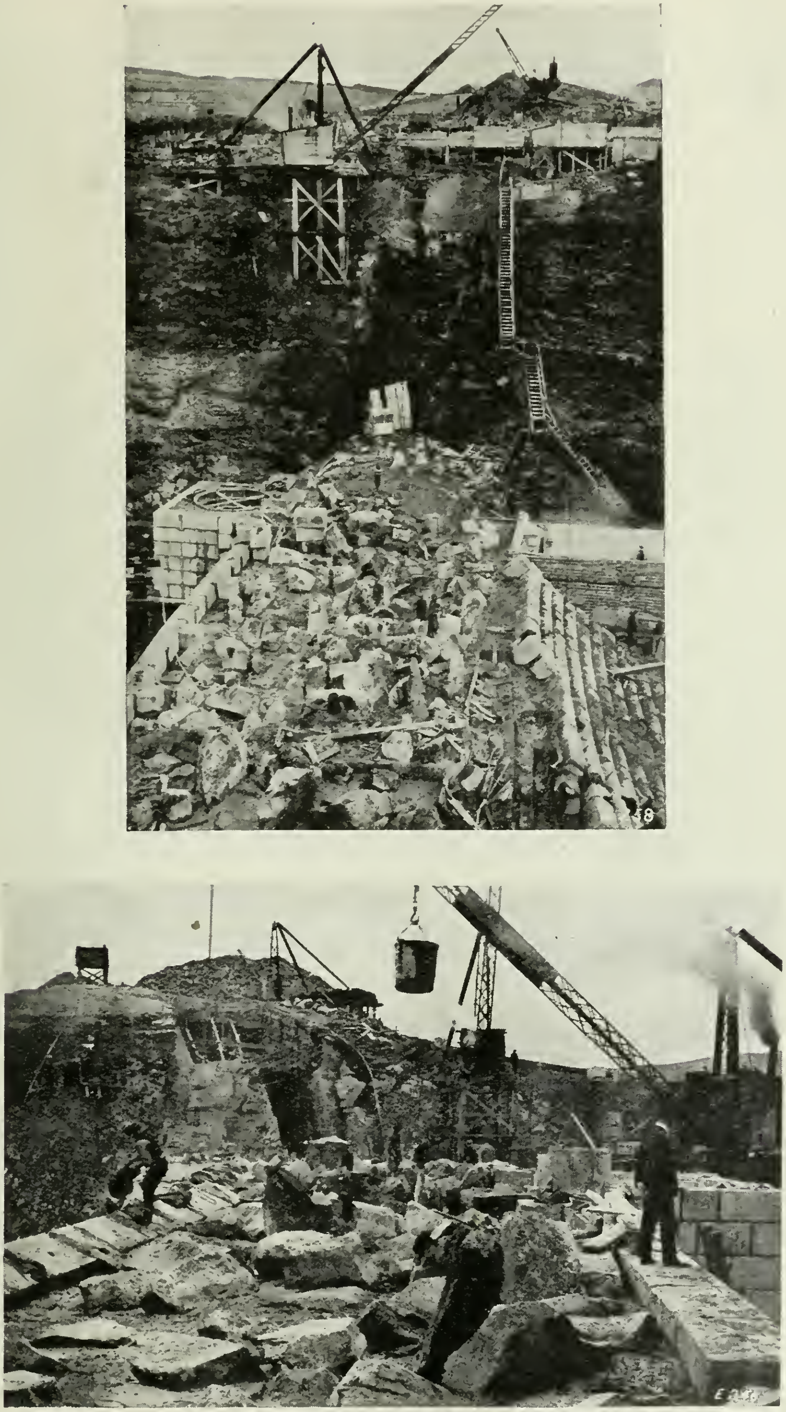


FIG. 8. SHOWING DEEPEST PORTION OF EXCAVATION FOR THE ALWEN DAM.



Figs. 9 and 10. Progress Views of Alwen Dam.

was then loaded with bricks to give uniform distribution of load, the other half being left unloaded except for the sand. Twelve tons of bricks were stacked without the arch showing signs of failure, the deflection in the centre amounting to ¼ in. Under these circumstances the maximum fibre tension occurred at a point 4 ft. 9 in. from the centre of the span and amounted to 730 lb. per sq. in. At this stage, owing to the difficulty of stacking the bricks higher on such a narrow base, the test was abandoned.

The roof is covered with sand from the excavation and finished off with soil to a level of 9 in. above the top of the domes and sown with grass-seed.

Access to the reservoir is provided by a shaft of brickwork of 9 ft. internal diameter, in which is situated a staircase formed of concrete blocks so made that when fitted together they form a central hollow column in which is placed the float of the level recorder. The walls of this shaft are pierced by six openings above water level to provide ventilation and to release the air trapped in the roof arches as the reservoir is filled. To prevent air being trapped in the domes, cast-iron vent pipes, 4 in. in diameter, are built in above water level between all the domes, so that the air can circulate freely from one dome to another and finally escape at the shaft.

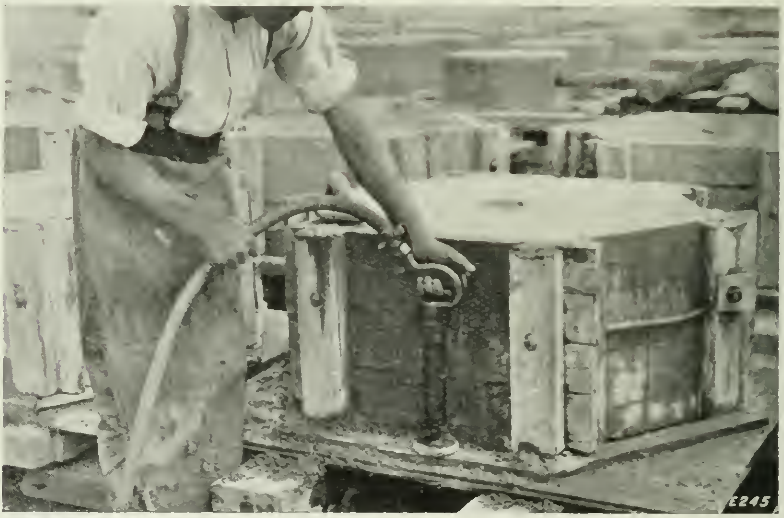


FIG. 11. PNEUMATIC HAMMER FOR VIBRATING MOULDS.

Side Walls.—The side walls consist of a series of horizontal arches springing from a steel plate 4 ft. in depth by 30 ft. 5¾ in. in length. The bases of the girders rest on concrete at a depth of 2 ft. below floor level, and each girder at its upper end is connected with the reinforcement of the groins of the domes. These girders are faced with special bricks and backed with concrete varying from 18 in. to 12 in. in thickness at the centre of the arch to 5 ft. at the springing. Between the brickwork and the concrete a layer of asphalte ¾ in. thick is inserted. The side walls are not reinforced except near the top, where a 2-in. by ½-in. longitudinal bar is attached to the plate girders.

THE ALWEN DAM.

The Alwen Dam, shown in its completed state in *Fig.* 7, and of which we are able to give some interesting progress photographs, is 100 ft. in height and approximately 400 ft. in length, curved in plan to a radius of 500 ft. It is faced with smooth concrete blocks on the water side and with rock-face concrete blocks on the downstream side. The overflow sill is divided into eight bays, each 20 ft. in length, and piers projecting above the sill carry a concrete roadway 10 ft. in width. The foundations were carried down to a depth of 55 ft., and the dam rises to about 100 ft. above the original bed of the stream. About 37,000 cubic yards of concrete were used in the construction of the dam. The method of construction is clearly shown in our illustrations. The lower courses of blocks were first placed in position and the centre filled with plums of local stone embedded in 5 to 1 concrete.

The concrete blocks for the water face of the dam were cast face downwards so that 3 to 1 concrete 6 in. thick formed the face, and the remainder of the block was of 5 to 1 concrete. In this case the 5 (or 3) parts mean that there were five parts of broken stone with as much sand added as was found experimentally to give a mixture of maximum density. In each course there are three stretchers and one header, the header being dovetailed into the hearting. The blocks were moulded with a special bevelled and tapered face joint which was raked out and caulked with dry cement mortar; a vertical 6-in. diameter hole was formed at each vertical joint and filled in with ordinary cement mortar.

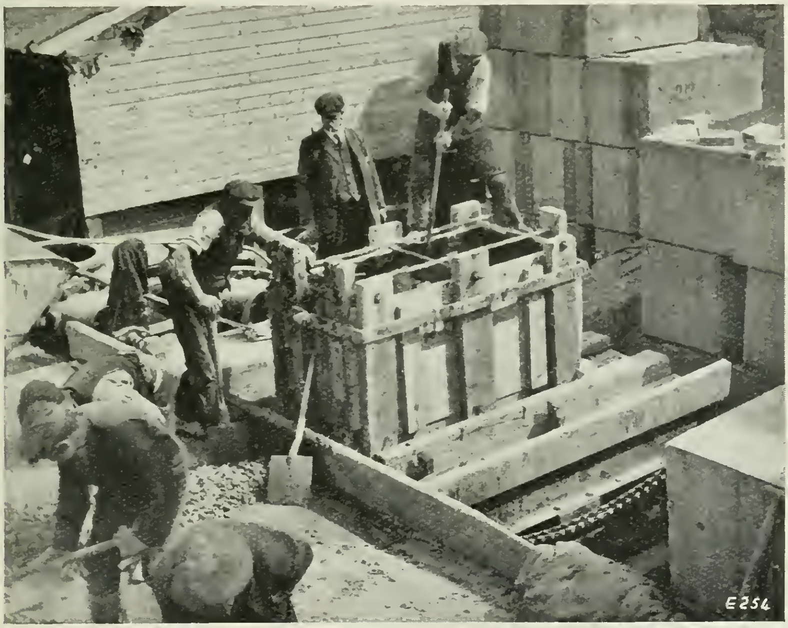


Fig. 12. Vibrating Table for Concrete Blocks.

Concrete Blocks.—The concrete blocks for the Alwen Dam and the pillars in the Cross Hill covered reservoir were all made on the site, and have proved very successful. This is chiefly attributed to the fact that they were vibrated during the process of moulding by special arrangements made by the contractors. Two methods were used. In one case the moulds were placed on a table which was vibrated by means of a cam arrangement under the table driven by a portable engine, which raised the table at one end and allowed it to drop (*Fig.* 12); and in the other case the pneumatic hammer was applied to the bed of the mould, which projected a few inches from the side (*Fig.* 11). The quality of the concrete produced by these methods has been very satisfactory and uniform, probably owing to the elimination to a large extent of the human element, upon which the quality of concrete punned by hand so much depends. A series of tests was carried out to ascertain whether there was any difference in the quality of the concrete produced by the use of the vibrated moulds and by hand punning, and these tests showed that the former method produced concrete with a crushing strength about 6 per cent. greater. The blocks used in the dam weighed from half to two tons each, and were allowed to mature for about three months before use.

THE NANT HEILYN WEIR.

The Nant Heilyn Weir (*Fig.* 13 and *Frontispiece*) is built across the Alwen Reservoir to provide a means of access from one side to the other. This weir, which is constructed of mass concrete faced with brick, is some 150 yards long. Similarly built piers are formed at intervals and support a concrete roadway. The concrete surface of this roadway is exposed to traffic, as also is the concrete roadway on the dam, and both are, we understand, showing excellent wearing qualities.

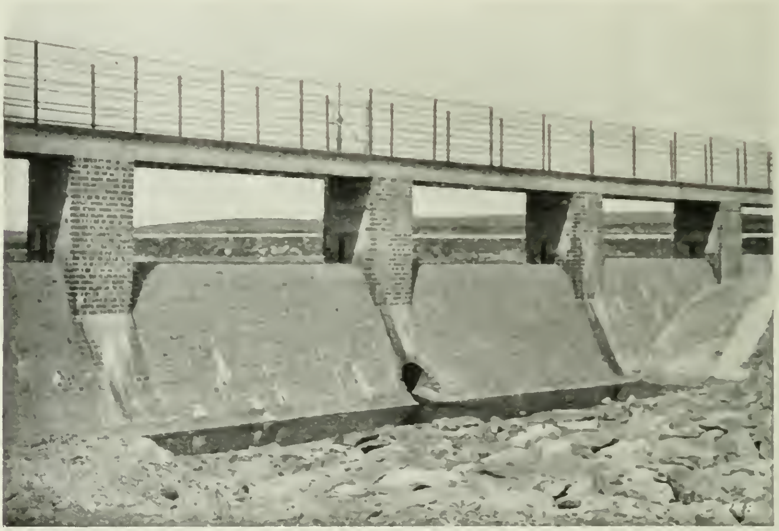


Fig. 13. Nant Heilyn Weir.

MEMORANDUM.

Large French Garage.—A motor garage recently completed entirely in reinforced concrete at Grenoble presents several interesting and novel features. The arched roof has a clear span of 28 metres between the supporting columns which enter into the construction of the outer walls. The haunches of the roof are formed by series of triangular frames constituting a kind of hammer-beam roof, the spaces between the vertical members being filled with glazing from end to end of the building and providing an abundance of natural light in addition to that admitted through windows in the side and end walls. The provision of the vertical glazing involved the division of the roof into three parts, for the purposes of design, and the inclination of the tie-beams at either side of the roof. The complete system constituted by two triangles and a curvilinear trapeze being geometrically indeformable, it was admissible to adopt and calculate it according to customary formulae for the strength of materials. However, to obtain a pleasing interior appearance, a curved profile was given to the inclined portions of the tie-beams so as to make the under side of the triangles in harmony with the curvature of the central portion of the roof. Consequently it was found desirable to employ vertical struts between the curved portion at the bottom and the arched members continuing the general curve of the roof over the top of the triangles. The roof covering is divided by longitudinal and transverse ribs into panels 5 metres by 6 metres in plan by 5 centimetres thick. In spite of its thinness, this covering is said to be of ample strength and perfectly watertight.

A REINFORCED CONCRETE BRIDGE.

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BRIDGE, NEW ARTERIAL ROAD, HASTINGS.

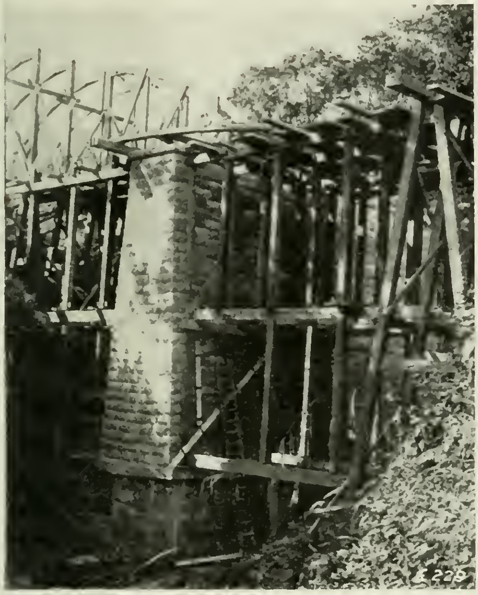


Fig. 1. Bridge in Course of Construction.

As may be seen from the accompanying illustrations, *Figs.* 1 and 2, the new bridge at Hastings is being constructed over a deep ravine, which is known as the Old Roar Gill; it is being built in conjunction with the new arterial road leading from the main London Road to the centre of Hastings.

Designed to withstand a rolling load of 24 tons, the bridge is constructed throughout of concrete reinforced with No. 68 3-in. Diamond Mesh Expanded Steel, which was supplied by The Expanded Metal Company, Limited, of London

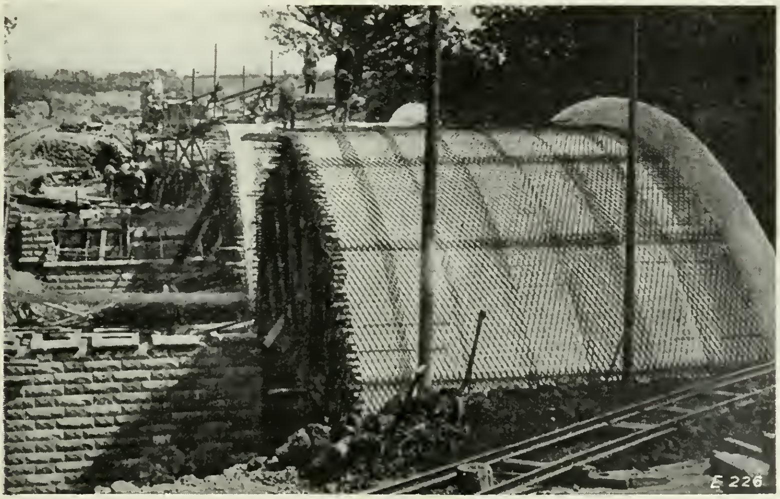


Fig. 2. Showing Reinforcement.

and West Hartlepool. There are two spans, each span being 45 ft., and the arch is 35 ft. wide, increased to a width of 40 ft. on the top deck between the parapets, the increased width being obtained by means of cantilevers which carry the footpath on either side.

Commenced last January, the work on the arterial road and the bridge was put in hand for the purpose of relief to the unemployed, and it is an interesting example of what may be done with practically all unskilled labour, providing there is good supervision. With the exception of the expanded steel, and the artificial stonework in the parapets (supplied by The Empire Stone Co., Ltd.), the entire structure is built of local materials.

The whole of the work is being carried out by direct labour to the designs and under the supervision of Mr. P. H. Palmer, M.Inst.C.E., the Borough Engineer of Hastings.

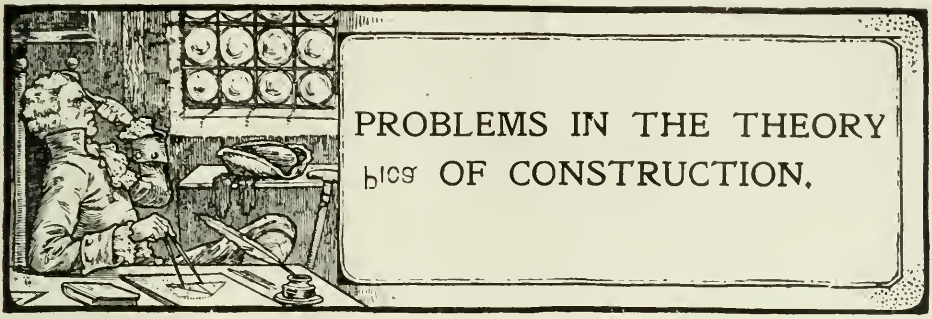
MEMORANDA.

The Modulus of Elasticity of Concrete.—In the discussions that have occurred at the last two annual meetings of the American Society for Testing Materials a sharp difference of opinion appears to exist as to the nature of the stress-strain curve within the usual working limits for concrete. It was contended by one speaker, Mr. Stanton Walker, of the Lewis Institute, at the 1919 meeting, that up to the so-called elastic limit of concrete this line was a curved one, concave to the axis of deformation, that is that the modulus of elasticity decreases with the stress. On the other hand, Prof. G. M. Williams, in addressing the Society in 1920, held that within the limit specified by Mr. Walker the stress-strain relation might be expressed by a straight line.

Another point at issue was the effect of consistency on the value of the modulus. Mr. Walker reported that an addition of 25 per cent. of water to a mixture of normal consistency would decrease the modulus of elasticity some 15 or 20 per cent., while at the same time the strength of the mixture would be decreased 35 or 40 per cent. Prof. Williams does not appear to think that differences in the consistency affect the value of the modulus appreciably, and although the stress-strain line might on the first application of the load be curved, on a second or additional application it would be sensibly straight.

New Bridge over the Dubissa River near Lidoviani.—In an article in *Eisenbau* particulars are given of this lattice-girder bridge which replaces a wooden military trestle bridge spanning the Dubissa valley (Kovno Province, Russia), which is here 570 m. (1,865 ft.) wide. The nine spans rest on two abutments and eight intermediate piers constructed of reinforced concrete and founded on reinforced concrete piles 13–15 m. (42–49 ft.) in length. The height of rail-level above mean-water level is 40 m. (130 ft.). The reinforcement of the rectangular piers is placed at the four corners and consists of light lattice-girder work of the mast type. The four masts of each pier were first erected and cross-tied, then enclosed in shuttering, and filled in with concrete. The piers measure 9 m. (29 ft. 6 in.) by 10·5 m. (34 ft. 3 in.) at the base, tapering to 6 m. (19 ft. 8 in.) by 7 m. (23 ft.) at the top. The main lattice girders, 63·4 m. (210 ft.) long, consist of two top booms of the box girder type, made up of plates and angles and measuring 404 mm. by 610 mm. (16 in. by 24 in.), and two bottom booms of the double-channel type, also made up of plates and angles and of the same over-all dimensions as the top boom. The top and bottom booms are connected by heavy diagonals and vertical struts at alternate joints, made up of joists, plates, and angles.

Concrete Railway Sleepers and Transmission Poles.—Reinforced concrete railway sleepers and electric transmission-line poles are being used in China on account of timber scarcity. The sleepers are reinforced with old mine cables, are cured under water, and are used to replace wooden sleepers on old tracks where the road-bed is well settled. The poles, tapering and square in section, are cast horizontally. They are 40 and 50 ft. tall, hollow for most of their length, and have some reinforcing rods extended above and below to serve as lightning conductors.



PROBLEMS IN THE THEORY OF CONSTRUCTION.

By EWART S. ANDREWS, B.Sc. Eng.; M.C.I.

CALCULATIONS FOR CONTINUOUS BEAMS WITH THIRD-POINT LOADING (*continued*).*

In the preceding article we dealt with continuous beams of two spans only. We now propose to deal similarly with beams which are continuous over three spans.

(2) THREE EQUAL SPANS.—*Fig.* 6 represents part of the framing plan of a building in which the arrangement of beams is in accordance with the case under consideration.

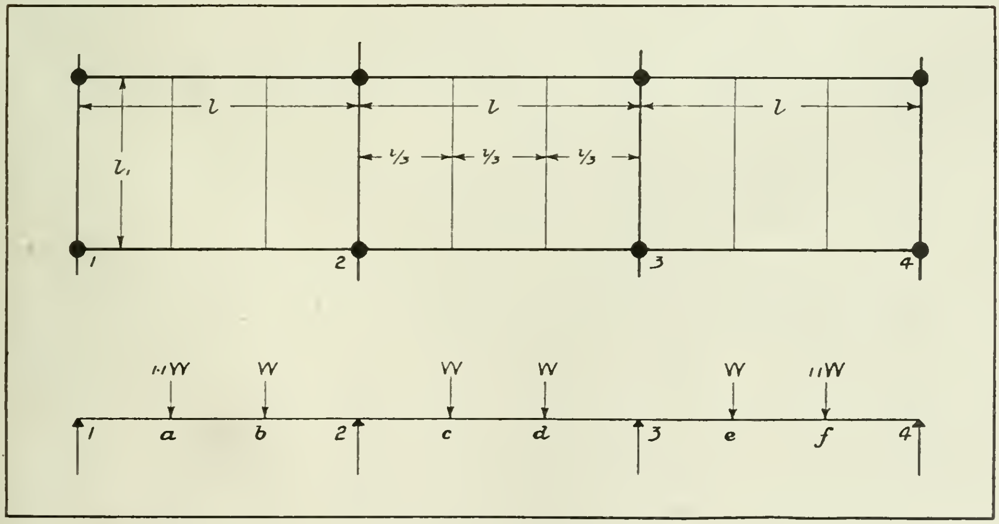


FIG. 6. LOADING DIAGRAM.

The continuous main beam 1 2 3 4 consists of three equal spans of length l and secondary beams of length l_1 run in at the third points a, b, etc.

As before we will take the load at the outermost third point of each end beam to be 1·1 W, and at the remaining third points to be W; giving the load diagram shown in *Fig.* 6.

Then the free Bending Moment Diagram for a loaded end span will be of the shape shown at the top right-hand side of *Fig.* 7.

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* Preceding article appeared Nov. 1920.

Then, height at a

$$= 1{\cdot}1W \cdot \frac{l}{3} \cdot \frac{2l}{3} \cdot \frac{1}{l} + \frac{W}{2} \cdot \frac{l}{3} \cdot \frac{2l}{3} \cdot \frac{1}{l}$$

$$= \frac{(2{\cdot}2+1)}{9} \cdot Wl$$

$$= \frac{3{\cdot}2\ Wl}{9}$$

$$= {\cdot}355Wl.$$

Then, height at b

$$= W \cdot \frac{l}{3} \cdot \frac{2l}{3} \cdot \frac{1}{l} + \frac{1{\cdot}1W}{2} \cdot \frac{l}{3} \cdot \frac{2l}{3} \cdot \frac{1}{l}$$

$$= \frac{(2+1{\cdot}1)}{9} \cdot Wl$$

$$= \frac{3{\cdot}1Wl}{9}$$

$$= {\cdot}344Wl.$$

Also for this diagram

$$A.y = \frac{2 \times 1{\cdot}1wl}{9} \cdot \frac{l}{2} \cdot \frac{4l}{9} + \frac{2Wl}{9} \cdot \frac{l}{2} \cdot \frac{5l}{9}$$

$$= \frac{4{\cdot}4Wl^3}{81} + \frac{5Wl^3}{81}$$

$$= \frac{9{\cdot}4Wl^3}{81}$$

$$= {\cdot}116Wl^3.$$

For the central span, height at c and d

$$= W \cdot \frac{l}{3} \cdot \frac{2l}{3} \cdot \frac{1}{l} + \frac{W}{2} \cdot \frac{l}{3} \cdot \frac{2l}{3} \cdot \frac{1}{l}$$

$$= \frac{2Wl}{9} + \frac{Wl}{9}$$

$$= \frac{Wl}{3}$$

$$= {\cdot}333Wl.$$

$\therefore$ for this diagram

$$A.y = \frac{2Wl}{3} \cdot \frac{l}{3} \cdot \frac{l}{2}$$

$$= \frac{Wl^3}{9}$$

$$= {\cdot}111Wl^3.$$

Then, as before, we shall use Clapeyron's Theorem of Three Moments

$$B_1l_1+2B_2(l_1+l_2)+B_3l_2=6\left\{\frac{A_1y_1}{l_1}+\frac{A_2y_2}{l_2}\right\} \quad . \quad . \quad . \quad (1),$$

where B_1, B_2, B_3 are the negative B.M.'s at the support, hereafter referred to as the "Support Moments;" and the other quantities as before.

There are four possible cases to be considered—

(*a*) All three spans loaded.
(*b*) First two spans loaded.
(*c*) End spans only loaded.
(*d*) Mid spans only loaded.

(*a*) In this case we have $B_{1_a}=B4_a=$zero, and from symmetry $B_{2_a}=B_{3_a}$.

$$\text{Then } 4B_{2_a}l+B_{3_a}l=\frac{6}{l}\left\{\frac{9\cdot4Wl^3}{81}+\frac{9Wl^3}{81}\right\}.$$

$$\text{i.e. } 5B_{2_a}=\frac{18\cdot4Wl^3}{81}\cdot\frac{6}{l_2}$$

$$\therefore\ B_{2_a}=\frac{36\cdot8Wl}{135}$$

$$=\cdot272Wl=B_{3_a}.$$

Then, the maximum intermediate B.M. on the end spans occurs at *a* and *f* and equals $(\cdot355-\cdot091)Wl$

$$=\cdot264Wl.$$

Also the B.M. on the centre span is equal to $(\cdot355-\cdot272)Wl$

$$=\cdot083Wl.$$

The completed diagram then comes as shown in *Fig.* 7.

(*b*) In this case since the loading is not symmetrical, B_2 and B_3 will not be equal, and we must find them by obtaining two equations from Clapeyron's Theorem.

$$\text{Then}\quad 4B_2+B_3=\frac{6}{l^2}\left(\frac{18\cdot4Wl^3}{81}\right)$$

$$=1\cdot36Wl$$

$$B_2+4B_3=\frac{6}{l^2}\left(\frac{Wl^3}{9}\right)$$

$$=\cdot667Wl.$$

$$\therefore\ 15B_2=(4\times1\cdot36-\cdot667)Wl$$

$$=4\cdot77Wl.$$

$$\therefore\ B_2=\cdot318Wl.$$

$$\therefore\ B_3=Wl(1\cdot36-4\times\cdot318)$$

$$=\cdot088Wl.$$

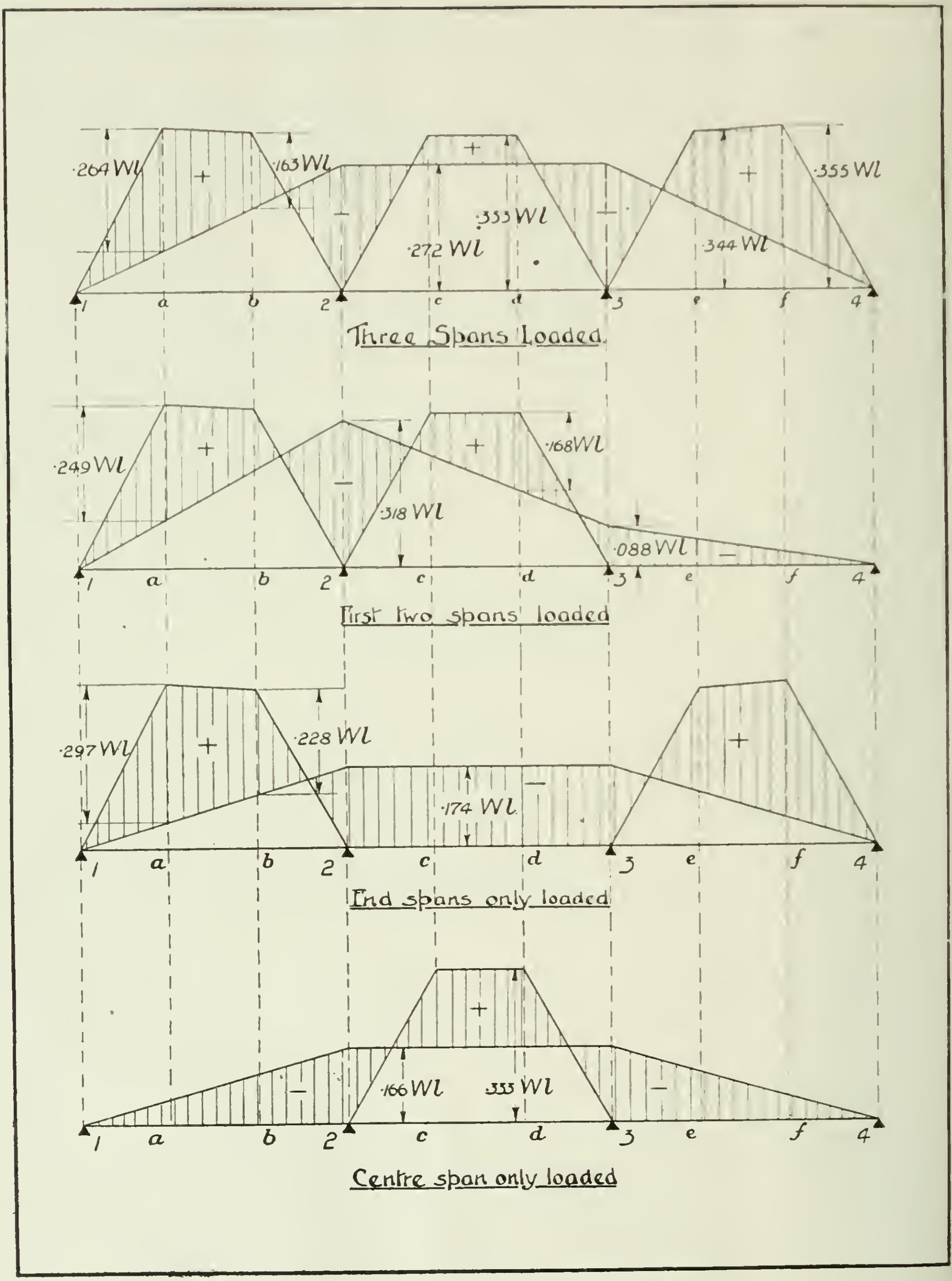


Fig. 7. Bending Moment Diagrams for various Load Conditions.

Then max. intermediate B.M. at *a* on end span

$$=Wl\left(\cdot 355-\frac{\cdot 318}{3}\right)$$
$$=Wl(\cdot 355-\cdot 106)$$
$$=\cdot 249Wl.$$

Then max. intermediate B.M. on centre span

$$=Wl\left\{\cdot 333-\left(\frac{\cdot 318-\cdot 088}{3}+\cdot 088\right)\right\}$$
$$=Wl(\cdot 333-\cdot 165)$$
$$=\cdot 168Wl.$$

Then max. B.M. on the unloaded span is the support moment.

The complete diagram is shown in *Fig.* 7.

(*c*) In this case $B_{1c}=B_{4c}$ and from symmetry $B_{2c}=B_{3c}$.

Ay for the unloaded centre span = zero.

Then
$$4B_{2c}=\frac{6}{l^2}\cdot\frac{9{\cdot}4Wl^3}{81}$$
$$=\cdot 174Wl$$
$$=B_3c.$$

Then maximum intermediate B.M. at *a* and *f*

$$=\left(\cdot 355-\frac{\cdot 174}{3}\right)Wl$$
$$=Wl(\cdot 355-\cdot 058)$$
$$=\cdot 297Wl.$$

The maximum B.M. on the centre span will of course be $\cdot 174Wl$, and the entire B.M. diagram comes as in *Fig.* 7.

(*d*) As before $B_{1d}=B_{4d}=o$, and from symmetry $B_{2d}=B_{3d}$; Ay for end spans$=o$.

Then
$$4B_{2d}=\frac{6}{l^2}\cdot\frac{Wl^3}{9}$$
$$\therefore\ B_{2d}=\cdot 167Wl$$
$$=B_{3d}.$$

Then maximum intermediate B.M. on the centre span$=(\cdot 333-\cdot 167)Wl$

$$=\cdot 167Wl,$$

the whole diagram coming as shown in *Fig.* 7.

From a consideration of the foregoing diagrams it will be seen that the greatest positive intermediate B.M. on an end span arises when the two end spans are loaded and the centre unloaded, and the greatest support B.M. arises when the centre span and one end span are loaded.

For the purpose of design we merely require to know the maximum B.M.'s which arise under any condition of loading.

Maximum possible + *ve* and — *ve* B.M.'s are shown to scale in *Fig.* 8, which can be obtained by superposing the various diagrams of *Fig.* 7.

From this it can be seen that the max. possible + *ve* intermediate B.M. at *a* is $\cdot 297Wl$ and max. possible —*ve* support B.M. is $\cdot 318Wl$.

For the centre span, max. possible —*ve* support B.M. is $\cdot 318Wl$, while the max. possible + *ve*·B.M. at *c* or *d* is $\cdot 168Wl$.

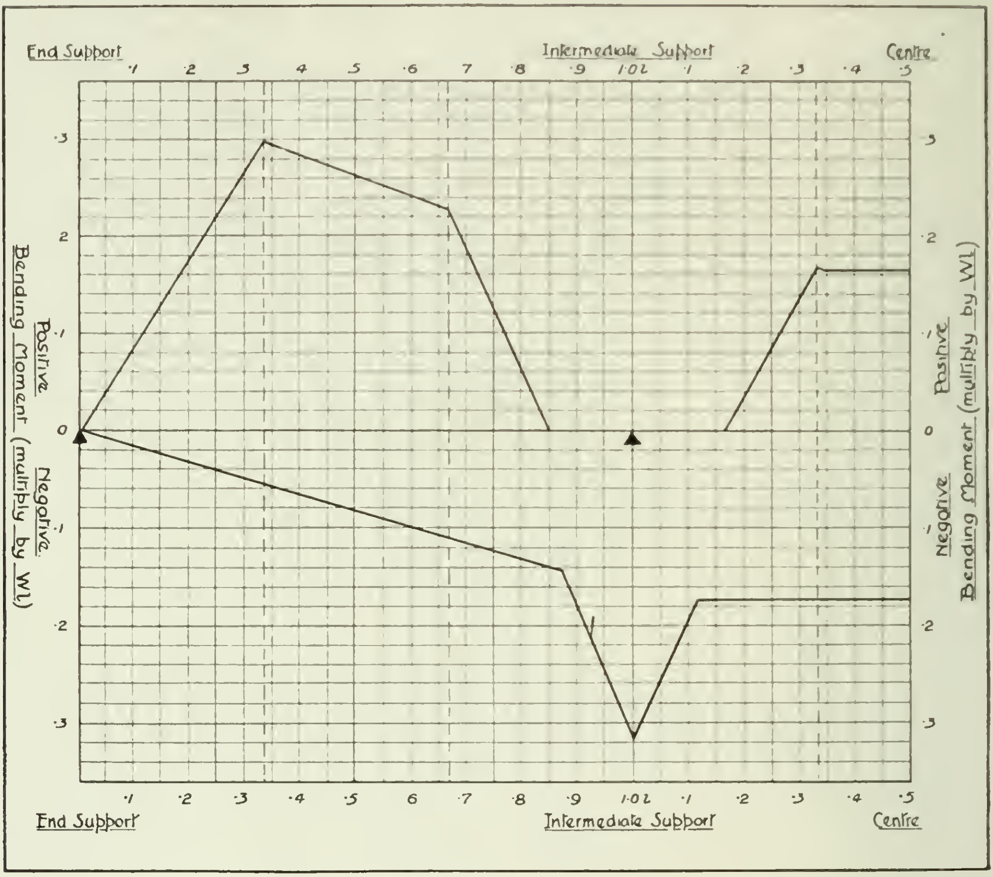


Fig. 8. Maximum Bending Moment Diagram.

Shear Forces.—Working by the usual method of adding to or subtracting from the " free " shears the difference in end B.M. divided by the span we obtain the following results :—

(*a*)
$$R1_a = 1{\cdot}066W - {\cdot}272W$$
$$= {\cdot}794W = R4_a.$$
$$R_{2_a} = 1{\cdot}033W + {\cdot}272W + W$$
$$= 2{\cdot}305W = \mathrm{R}_3\,.$$

(*b*)
$$R_{1_b} = 1{\cdot}066W - {\cdot}318W$$
$$= {\cdot}748W.$$
$$R_{2_b} = 1{\cdot}033W + {\cdot}318W + W + ({\cdot}318 - {\cdot}088)W$$
$$= 1{\cdot}351W + 1{\cdot}23W$$
$$= 2{\cdot}581W.$$

$$\begin{aligned} R_3 &= W - \cdot 23W + 0 + \cdot 088W \\ &= \cdot 77W + \cdot 088W \\ &= \cdot 858W. \\ R_4 &= 0 - \cdot 088W \\ &= - \cdot 088W. \end{aligned}$$

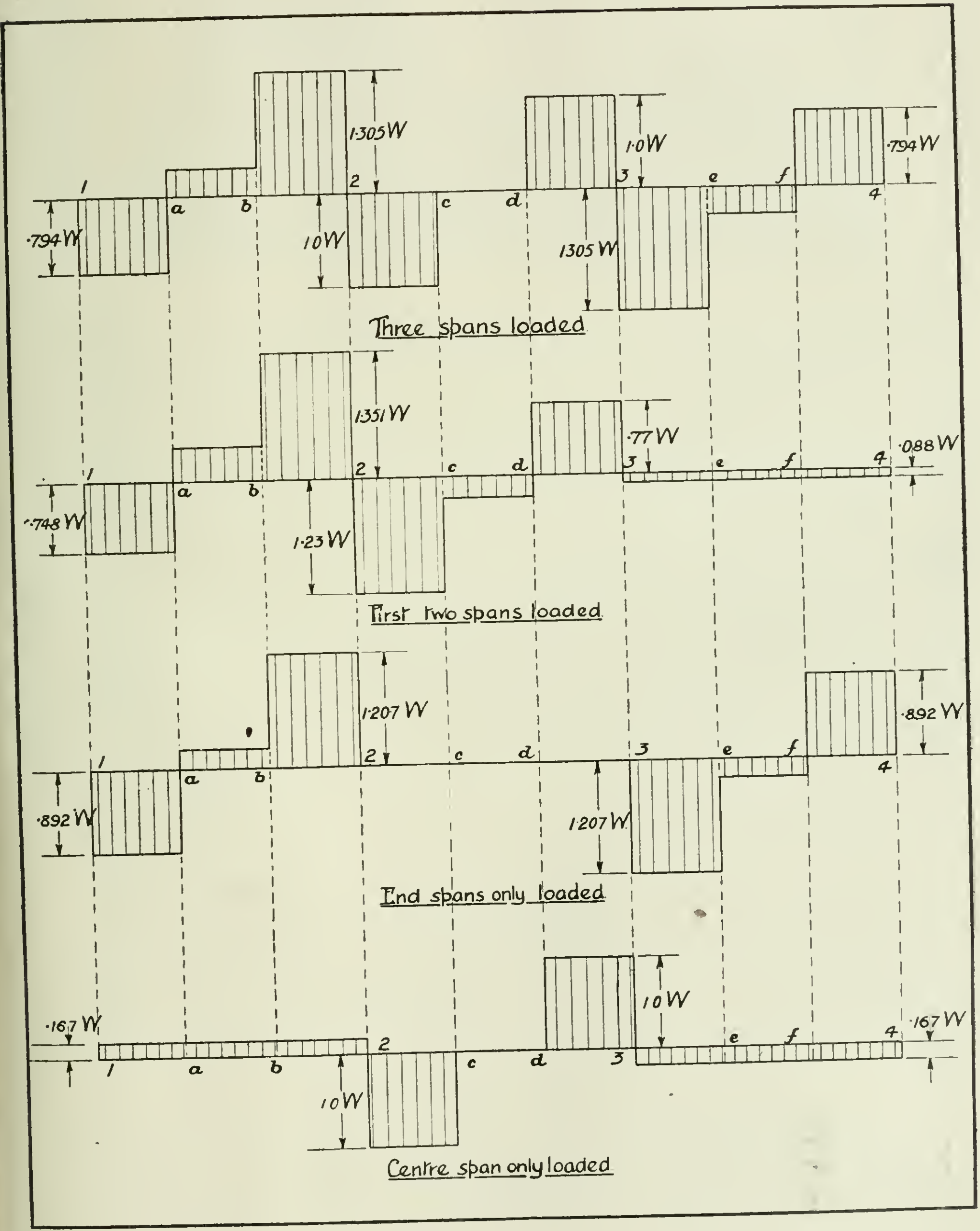


FIG. 9. SHEAR DIAGRAMS.

This indicates that the beam reaction is upwards, and so the beam must be tied down

(c) $R_{1c} = 1{\cdot}066W - {\cdot}174W$
$= {\cdot}892W = R_{4c}$
$R_{2c} = 1{\cdot}033W + {\cdot}1274W$
$= 1{\cdot}207W = R_{3c}.$

(d) $R_{1d} = 0 - {\cdot}167W$
$= -{\cdot}167W = R_{4d}.$
$R_{2d} = {\cdot}167W + W$
$= 1{\cdot}67W = R_{3d}.$

These are all shown in *Fig.* 9.

Taking now the maximum +*ve* and —*ve* values of the shear from the above figures and plotting them, we obtain the diagram shown in *Fig.* 10.

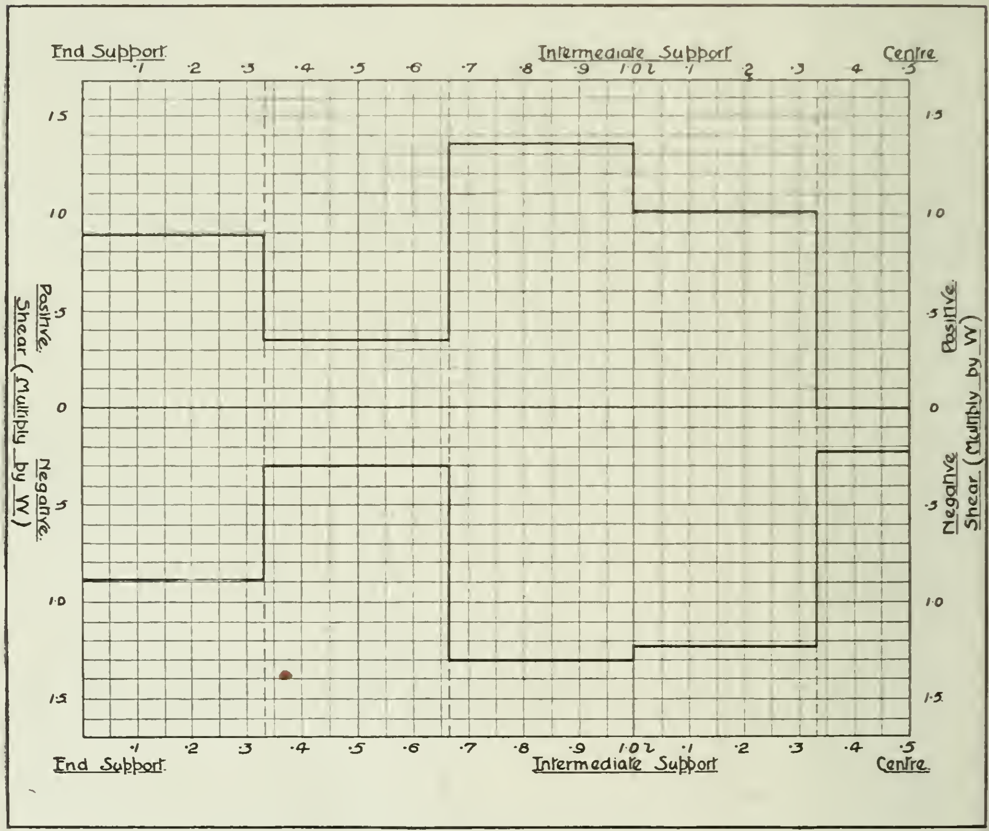
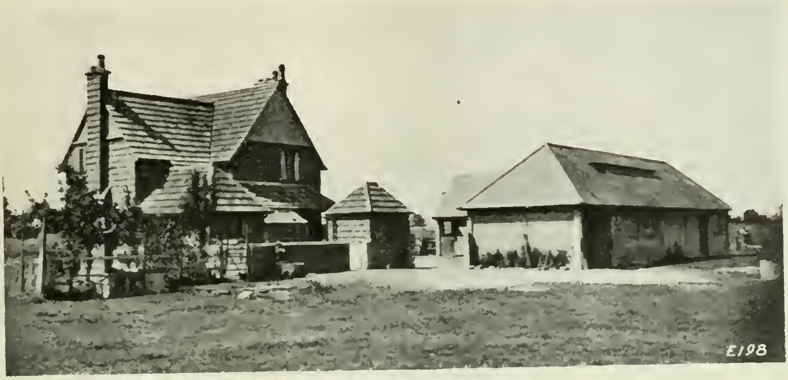


FIG. 10. MAXIMUM SHEAR DIAGRAM.

It should be remembered, however, that we have calculated shears for an unloaded span at the right-hand end, and the shear diagram for that case must be turned completely round and the max. values taken in that case also in order to cover all the possibilities.



THE USE OF CONCRETE ON FARM AND ESTATE.

By Capt. W. J. PULFORD, County Land Agent, Shire Hall, Shrewsbury.

THERE has been considerable argument and difference of opinion in the past regarding the advisability of using concrete for the erection of cottages. Such arguments and objections scarcely hold good to-day, but the following notes made recently upon inspecting a cottage and farm buildings erected in 1914 may be of interest.

THE COTTAGE OR FARMHOUSE.

I will deal firstly with the cottage or farmhouse, this being constructed upon an entirely different system to that employed on the farm buildings.

The cottage consists of living-room, parlour, scullery and a dairy with three bedrooms over. There are detached coal-house and W.C. The planning is convenient and suited to the requirements of a small holding of about 25 to 30 acres of land.

The cottage is constructed with concrete walls built up of blocks approximately 4½ in. thick, with a 2-in. cavity, the outer and inner slabs being tied together with ordinary galvanised wall ties.

The blocks were all cast on the site in one of the popular block machines. The aggregate for the outer block is fine gravel finished with a rock face. The cottage was erected complete in eight weeks.

The roof is covered with sand and cement tiles coloured red.

Inside, solid concrete floors were used, finished with a fine, smooth surface; for the ceilings, cement and asbestos fibre sheets with a 2-in. fillet over the joint.

It will be remembered that in the Report of the Departmental Committee (1913) appointed to report on buildings for Small Holdings in England and Wales—it was stated that while appreciating that concrete was an excellent material for use in the construction of homesteads, most of the examples examined by the Committee were not a success for various reasons, mainly on account of dampness.

The present condition of the house is as follows :—

(1) *The Walls.*—The exterior walls have weathered slightly and are of a pleasing tint. I could discover no signs of cracks or disintegration of any kind.

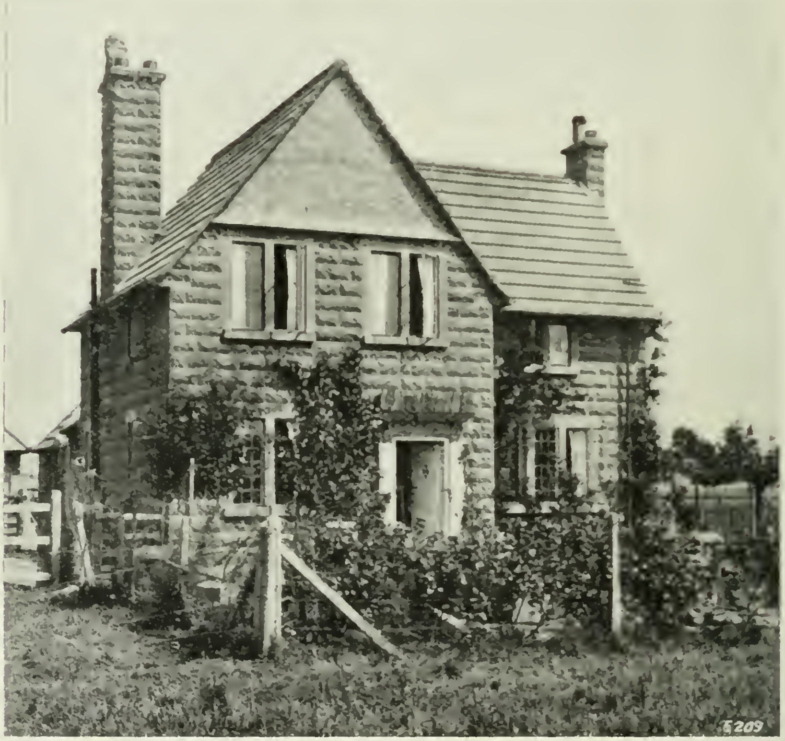
(2) *The Roof.*—The roof tiles, as before stated, are composed of cement and sand and coloured red; one or two of these tiles were broken when the house was used by German prisoners during the war, otherwise they are as sound as when first laid. The colour is the same, no sign being visible of its washing off.

The cement fillets to hips are not very artistic, and perhaps it would have made a neater job if half round hip tiles had been used.

(3) The internal floors and the paving round the cottage are still perfect.

(4) Inside, the house is structurally sound and perfect. It was surprising to see that the fibre sheet ceilings with the narrow fillet over the joints had stood so well—no signs of shrinkage being visible and the panels formed by the fillets are quite a pleasing feature.

There is no sign of dampness anywhere, and the wall papers are quite free from any sign of mould or stain.



View of South Cottage.

The wife of the tenant informs me that she has never seen any signs of condensation, and in fact that she has never lived in a house so free from dampness.

There is no reason whatever why a concrete house should not be of pleasing design. Frequently one sees concrete houses built of large rock faced blocks simulating a wall used in sea defence or a Nile dam (but which actually may be quite porous) with ugly bay windows and a repulsive front entrance.

The cottage in question would have been more pleasing with less of the rock face about it, but the general lines are pleasing.

From my inspection, I am satisfied :—

(1) That concrete is eminently suitable for the construction of cottages, when common-sense rules and care are observed in design and construction.

(2) That where a suitable aggregate can be obtained on or near the site, concrete

is cheaper than brickwork and less skilled labour is required, but that skilled and conscientious supervision is absolutely necessary.

(3) That if hollow walls are used with a complete cavity, dampness and condensation are practically impossible.

THE FARM BUILDINGS.

The construction here used was at the time of erection rather an experiment, but is now, I believe, practised more generally.

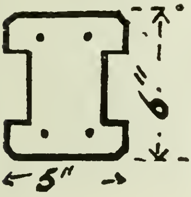
The accommodation, like the house, is suited to a dairy holding of from 25 to 30 acres of land.

Provision was made for ten cows with a conveniently situated mixing house, a loose box, stall stable and two pig boxes which on occasion could be used for calves; also a cart shed.

The walls were erected as follows :—

A concrete foundation approximately 18 in. in width and 6 in. thick was laid of cement concrete.

At the corners and at 10 ft. centres four indented bars were erected vertically. Round these bars a casing was erected about 3 ft. in height. This when filled with semi-dry concrete formed a pier of the following section and dimensions :—



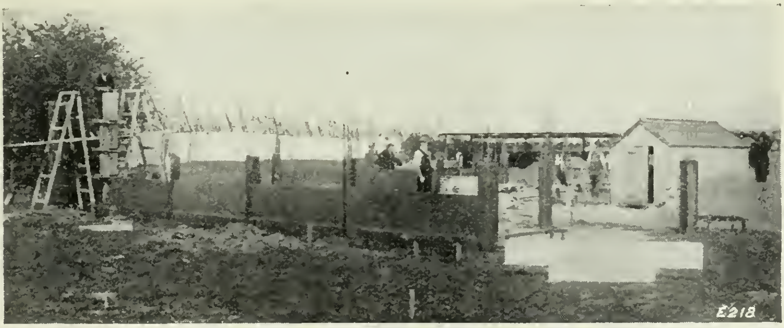
The panels between piers were then carried up two feet at a time by means of shuttering filled in with semi-dry concrete punned. Vertical and horizontal reinforcement bars were built into panels at 12-in. centres.

In using concrete in the semi-dry state, the casings or shutterings can be removed, and the building erected much more quickly than with the wet or slurry method, but, to ensure success, it must be sufficiently watered after the frame or shuttering is removed.

The roofs are covered in with red cement asbestos slates.

The floors are formed with cement and granite chippings laid to falls and grooved to prevent the animals slipping.

The walls were washed over with cement wash to give uniformity of colour.



FARM BUILDINGS IN COURSE OF CONSTRUCTION.
(*Note Method of Construction.*)

On examination, after a period of seven years, the walls were found to be perfectly sound.

The concrete is as hard as it would have been had the usual wet method been used. In one or two places the cement wash had cracked where the junction of one layer of material was placed upon the previous layer when the mould was moved up, but was so thin that it can only be considered as a wind crack—and does not appear to go any deeper than the cement wash. The roofs and floor are still perfect.

In my opinion, farm buildings constructed either by this method or a method I hope to describe later in which the posts and panels are cast wet previous to erection, are superior to those erected in brick, both as regards cost, durability and from a sanitary point of view. I find the cost—from tenders received for the same job alternatively brick or concrete—shows a saving of at least 25 per cent. in favour of reinforced concrete.

The following actual figures illustrate this point :—

Tenders recently received for farm buildings to exactly the same plan and specification excepting that in No. 3 reinforced concrete on the post and panel system is substituted for brickwork.

View of Farm Buildings and Yard. The Fence is Reinforced Concrete.

View from South-East.

		£	s.	d.
Tender	No. 1 in Brickwork	2,146	0	0
,,	No. 2 in Brickwork	2,224	0	0
,,	No. 3 Concrete	1,530	0	0

which shows a saving in capital expenditure of nearly 30 per cent. or—supposing the capital had to be borrowed as a 60 year loan on a 6½ per cent. basis, a saving of £40 18s. per annum !

Only a few years ago the Local Government Board were very wary in sanctioning loans for reinforced concrete buildings and, as recently as 1911, would only sanction loans for about 21 years' duration. The period now, for Land Settlement, is 60 years, which is the same as for brickwork.

About nine years ago the writer had to submit plans of a small reservoir to the Local Government Board for the purpose of obtaining that body's sanction to a loan. The reservoir top was a flat roof of reinforced concrete.

After the plans were submitted, a letter was received requesting that the " Person " who prepared the plan should proceed to London to interview a high official of the Board. " Did you do this ? " " Yes ! " " Then you know nothing about it, sir—nothing at all. That top won't last five minutes, the iron will rust and the whole thing collapse ! " I had rather a bad ten minutes . . . but when I told him the job was actually completed ! . . . However I was perfectly satisfied with my design, and the roof hasn't fallen in yet.

Just before the above episode, I was in a shipyard by a tidal river in Essex when an old yacht was being broken up—part of the ballast of the yacht had been composed of concrete—in breaking up the concrete it was found that the aggregate, or part of it, was composed of the " Punchings " or round pieces of iron cut out of the iron sheets when making holes for rivets, bolts, etc. The cut edges of these punchings were bright, although the concrete ballast itself had been covered with bilge water for years, as, during the latter end of her life the old iron boat had been used as a fishing smack.

This boat had certainly been in existence fifty years, and was built by the late Mr. E. H. Bentall, a pioneer in private house concrete building, he having built his large residence—" The Towers," Heybridge—and a large number of cottages, of that material in the seventies of last century.

MEMORANDA.

Proposed Concrete Housing Scheme at Londonderry.—The North of Ireland Shipbuilding Co., Ltd., of Londonderry, is considering the carrying out of an extensive housing scheme at Londonderry, providing the work can be finished in time to secure the Government subsidy. A total of 400 houses are contemplated, all to be built in concrete, and four types of plans have been submitted to the Londonderry Corporation for approval.

Experimental Concrete Houses at Dublin.—The Dublin Corporation is building twelve experimental concrete houses on the Donegal Road site. Messrs. Stewart & Partners are the contractors.

Circular Concrete Structures.—What is claimed to be a structurally sound and economical, as well as a simple, method of erecting circular concrete buildings, was described at a recent convention of the American Concrete Products Association. The system, which is stated to be specially suitable for silos, bins, water-tanks, and such-like structures, consists of concrete slabs, 30 in. high by 10 in. wide by 2½in. thick, made in the factory and erected on the site. The slabs are convex in shape and are made with one convex and one concave edge. After the footings have been dug out, these slabs are set up on end around the circular plan, and grouted together where they interlock with one another at the sides. In the first row to be put in position, shorter slabs are placed alternately with those 30 in. long in order to ensure that joint is broken horizontally throughout the structure ; the vertical joints are unbroken throughout. Greater stability is secured by encircling the building with bands of hoop iron to every slab, that is, at 30 in. intervals from the foundation to the top. Silos constructed on this system have been in use during the past two or three years, and, it is stated, have given every satisfaction as regards strength. An instance is cited of a tornado which occurred in 1919, and, although whole villages were razed to the ground, silos built by this method remained intact. It is claimed that a 100-ton silo can be built in this manner by three men in three days, and no special skill is required. The slabs are made by hand or machine according to usual practice.

THE FIRE RESISTANCE OF CONCRETE AND REINFORCED CONCRETE.

The following is an abstract from a paper read by Mr. D. W. Wood before the Junior Institution of Engineers and summarises the details and results of tests carried out by the British Fire Prevention Committee with the aid of grants made by the Scientific and Industrial Research Department. Our illustrations in succeeding issues are reproduced from the Red Books of the British Fire Prevention Committee dealing with these tests, and we are indebted to the Controller of H.M. Stationery Office for his permission to make use of these photographs.—Ed.

INTRODUCTORY.

General.

The tests which the British Fire Prevention Committee carried out to ascertain the fire-resisting properties of concrete and reinforced concrete composed of various aggregates and of differing proportions commenced October 1917 and lasted till September 1919. In all there were approximately 200 tests together with about fifty smaller tests which did not prove quite reliable nor of much service. The Committee carried out the work with the aid of grants from the Department of Scientific and Industrial Research, who also bore the greater part of the cost, and representatives of various Technical Societies, such as the Royal Institute of British Architects, the Surveyors' Institution, the Society of Architects, the Junior Institution of Engineers, the Concrete Institute, etc., were co-opted on the " Commission."

Work Undertaken.

There were several series of tests. Plain Concrete Slabs—" C " Reinforced Concrete Slabs—" R.C " ; and Conductivity Slabs—" C.C " The various slabs were numbered with the respective indicating letter preceding the number.

" X " implies that a slab was about twelve months old at time of test, and " R " that it had been repaired and re-tested.

Reports.

Very exhaustive reports fully illustrated by reproductions of photographs have been prepared on each test and these have been published by H.M. Stationery Office in the usual " Red Book " form adopted by the Committee.*

BRIEF DESCRIPTION OF THE TESTING PLANT AND GENERAL ARRANGEMENTS.

Testing Station.

The Testing Station the Committee had at St. John's Wood comprised a detached house and grounds. The old house was used as offices and part contained the electrical apparatus for recording the temperatures. In the grounds were the three testing huts built of stock brick with concrete floors on brick arches. The roofs were formed of the concrete or reinforced concrete slabs or " floors " that were to be the subject of the tests. The slabs were allowed to season for a period of approximately sixty to ninety days, but a certain number of reinforced concrete slabs were made in duplicate in order that one of each of these pairs should not be tested till it had had twelve months' seasoning. The slabs (excepting the small ones used for conductivity tests) were then loaded with concrete blocks to give loads per foot super of 168 lb. for the reinforced slabs, except Slabs Nos. R.C. 9 and 10, which were loaded 280 lb. and 224 lb. for the plain concrete slabs, these being recognised as the approximate loads floors in factories would have to carry.

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* A list of these reports is given at the conclusion of this abstract.

The fire tests for the plain concrete lasted three or four hours as was previously determined, and four hours for the reinforced concrete slabs, and the heat rose from the temperature of the day to approximately 900°F. in the first thirty minutes, 1200° in the next thirty minutes, 1500° a further thirty minutes (i.e. one-and-a-half hours in all), and an additional 100° for each subsequent thirty minutes, so that not more than 1800°F. was reached for the three hours' tests, and 2000°F. for the four hours' tests.

Certain of the slabs after the fire tests were subjected to two jets of water from a small steam fire engine, and the water was applied for two minutes in the case of the plain concrete slabs which had been subjected to three hours of fire, and five minutes in the others, both plain and reinforced.

Standards for Tests.

The basis on which the tests were carried out was that laid down by the International Fire Service Congress held in London in 1903, which provided for the time that the test should last, the minimum temperature to be attained, the load which the floor should carry and the time during which water should be applied after the fire test.

Aggregates.

The coarse materials were bought in the open market.

The sand was all from pits at West Drayton. As will be noticed later, sand was not always used as a " fine " aggregate, sometimes the " fine " consisted of the same material as the " coarse," whilst in others varying fine stuff was used, but mostly fine coke breeze or fine broken brick.

The Portland cement was supplied by the Associated Portland Cement Manufacturers (1900) Ltd., and known as their " Ferrocrete " brand and complied with the British Standard Specification. It was slow setting.

The water was from the mains of the Metropolitan Water Board.

The proportioning of the materials was all by volume and not by weight, which would probably have been more correct, but this is rarely done in everyday practice. The mixing was all done by hand and the concrete was laid in a moderately wet condition. Of course the quantity of water used varied considerably as some of the aggregates were of a more thirsty nature than others.

As regards the coarse aggregates, their geological characteristics were all thoroughly investigated by Dr. Holmes, and the physical properties by Dr. Gulliver of the well known Kirkcaldy Laboratories.

The size of the coarse aggregate was mostly ¾ in. to 3/16 in., and the maximum size of the sand 3/16 in.

In some coarse aggregates, mostly broken brick, it was found desirable to increase the size to 1¼ in. or 1½ in., as the mixing and tamping operations tended unduly to reduce the size of the pieces.

Geological Data.*

More fully to understand the properties of the aggregates a little time must be devoted to the geological aspect. It may be said that there are two great classes of rocks :—

(*a*) Sedimentary or Conglomerate—a collection of pebbles or broken pieces of rock or mineral in a matrix—like sandstone, clay and shale, and these are the clastic or fragmental rocks. The mineral fragments are generally pieces of crystals, such as quartz, felspar, mica, etc. Limestone is a clastic rock made of the broken hard parts of animals and plants.

(*b*) Igneous or Granite, Dolerite and Basalts—formed of unbroken crystals—

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* Abridged from Dr. Holmes' Red Book, No. 256.

these are the crystalline rocks—common minerals in these are quartz, felspar, mica, augite, hornblende, olivine and magnetite.

The composition of all these can be summarised in the following tables :—

MINERAL COMPOSITION OF AVERAGE ROCK TYPES.

Minerals.	Granite.	Dolerite and Basalt.	Sandstone.	Limestone.	Shale.
Quartz	31·3	—	69·8	3·7	31·9
Felspar	52·3	46·2	8·4	2·2	17·6
Mica	11·5	—	1·2	—	18·4
Clay Minerals	—	—	8·0	—	16·4
Hornblende	2·4	—	—	—	—
Augite	—	36·9	—	—	—
Olivine	—	7·6	—	—	—
Calcite and Dolomite	—	—	10·6	92·8	7·9
Iron Ores	2·0	6·5	1·7	0·1	5·4
Other Accessories	0·5	2·8	0·3	0·3	2·4

PHYSICAL PROPERTIES OF THE CONCRETES.*

The average weights of several of the different kinds of concrete were—

Thames Ballast	11 specimens	138·5 lb.	per cubic ft.
Sandstones	6 ,,	135·8 lb.	,,
Broken Brick	12 ,,	113·1 lb.	,,
Gault Clay	4 ,,	113·3 lb.	,,
Furnace Clinker	4 ,,	111·1 lb.	,,
Pan Breeze	4 ,,	102·9 lb.	,,
Coke Breeze	10 ,,	90·4 lb.	,,

The average crushing strengths of the above concretes at ninety days were—

Thames Ballast	2,286 lb.	per sq. in.
Sandstones	2,465 lb.	,,
Broken Brick	2,738 lb.	,,
Gault Clay	2,430 lb.	,,
Furnace Clinker	2,612 lb.	,,
Pan Breeze	1,977 lb.	,,
Coke Breeze	2,216 lb.	,,

PLAIN CONCRETE.

The particulars of the tests with plain concrete may now be considered.

All the ninety-two plain concrete slabs were of a uniform size, the area of the soffit exposed to the fire being 10 ft. 0 in. × 2 ft. 9 in., and they were about 5½ in. thick. Of these, forty-four slabs were of different aggregates of a 4 : 2 : 1 mixture loaded with 224 lb. per ft. super, and tested for three hours with a maximum temperature of 1800°F., followed by an application of water from a steam fire engine at the close of the test for two minutes. Several slabs of identical mixtures were tried as repeat tests. In addition a further twelve of these slabs were made in duplicate and were similarly tested, but no water was applied after the fire test.

Besides these, twenty-two slabs of various aggregates which had been tested in the previous series were also tested for four hours, followed by the application of water for five minutes. These slabs were loaded with 280 lb. per ft. super, and the mixtures were varied. In a further fourteen instances special protective coverings of different forms of plaster or concrete had been applied to the soffits.

SETTING.

The concrete was allowed approximately sixty to ninety days for setting. In the case of some of the reinforced concrete floors a twelve months' setting period was allowed, but this will be referred to later.

(*To be continued*).

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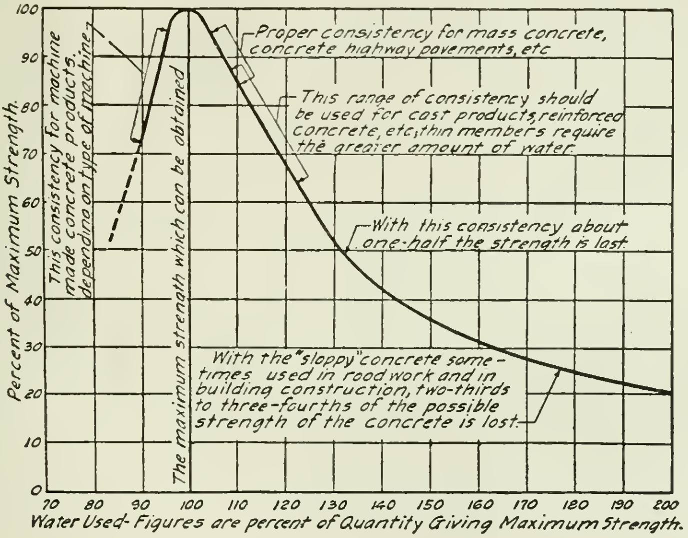
* Based on Dr. Gulliver's Red Book, No. 253.

HOW THE QUANTITY OF MIXING WATER AFFECTS THE STRENGTH OF CONCRETE.

By DUFF A. ABRAMS.

Few realise the important part played by the *quantity* of mixing water in determining the strength and other properties of concrete. The accompanying diagram (from tests made at the Structural Materials Research Laboratory, Lewis Institute, Chicago) shows that there is a certain quantity of mixing water which gives maximum strength of concrete for a given mixture and materials. Increasing or decreasing this quantity is accompanied by a rapid deduction in the strength of the concrete.

For example, if 20 per cent. more water is used than that required for maximum strength the strength of the resulting concrete will be reduced by about 30 per cent.; if 30 per cent. more water is used, only about one-half the possible strength of the concrete will be realised. Not only does an excess of mixing water reduce strength and resistance to wear or abrasion on floors or other pavements, but it amounts to a needless waste of cement. For plastic concrete the use of 1 pint of water more than necessary in a 1-sack batch produces the same reduction in strength as if we should leave out 2 or 3 pounds of cement.



In most types of construction we cannot use concrete as dry as that giving maximum strength, since more water must be used in order to secure a workable concrete. It is important, however, that we sacrifice as little strength as possible in order to secure the necessary workability, by using the smallest quantity of mixing water that will produce a concrete which can be placed in the work.

In practice we cannot specify a fixed volume of water for each batch of concrete, due to variations in moisture content and grading of aggregates. We can, however, specify minimum and maximum quantities that closely approximate the amount of water required under average conditions. The accompanying table shows these quantities for a wide range of mixtures. It is assumed that the aggregate is graded up to 1½ in.

Mix.		Approximate Mix as Usually Expressed			Water Required (Gallons per Sack of Cement).*	
Cement.	Volume of Aggregate after Mixing.	Cement.	Aggregate			
			Fine.	Coarse.	Minimum	Maximum
1	3	1	1¼	2½	5	5½
1	4	1	1½	3	5½	6
1	4½	1	2	3	5¾	6¼
1	5	1	2	4	6	6½
1	6½	1	2½	5	7¼	7¾
1	7¾	1	3	6	8¼	8¾

* The sack referred to is the American sack of 94 lbs.

The degree of workability which a concrete mixture must possess may have to be varied slightly, depending on the character of the work for which the concrete is to be used, but the following guide will always apply:

Use the smallest quantity of mixing water that will produce a workable mix.

Methods of proportioning, mixing, placing or finishing concrete which will enable the builder to keep the water content within the lowest practicable limits are of the utmost importance because of the increased strength and resistance to wear thus obtained.

In general metal spouts or chutes should have a slope of 35 degrees or more with the horizontal in order that the concrete may be placed without the use of too much water.

MEMORANDA.

Novel Method of Concrete Roof Construction.—A recent issue of the *American Architect* contains an account of an interesting experiment in the construction of a concrete roof over a large factory building in Detroit. The existing concrete roof was subjected to unusually severe conditions, in that it was used for cooling the water for the engine house. This water is pumped into two pipe lines supported on brick piers on the roof, and is projected into the air from two spray heads, and is cooled while falling to the roof. The roof is 900 ft. by 85 ft., and is laid with a fall of 18 in. to a sump in the centre, into which the cooled water runs. Thus the roof is subjected to continuous flooding by hot water during the working days, whilst on other days it is dry and often exposed to a temperature as low as 20 degrees below zero. The existing roof cracked owing to the expansion and contraction set up by these conditions, and a new roof was built above it. First a layer of sand ½ in. deep was placed over the existing roof, and on this were placed two layers of wire mesh reinforcement held one above the other by wires. This mesh reinforcement was then filled with concrete by a cement gun, a layer of tarred felt having first been placed over the sand to prevent the latter being disturbed by the blast of the cement gun. The piers and pipes were then erected on this upper roof as before. Thus the top of the roof, which is subjected to the great changes in temperature, is practically a slab resting on a layer of sand laid over the original roof, and, as it is nowhere fixed, it is free to expand and contract without reference to any other part of the building. Owing to the large size of the area to be covered, the second roof is laid in sections, with expansion joints between.

Concrete Fish Troughs.—*The Times* Engineering Supplement reports that in the Juneau hatchery of the Alaska Territorial Fish Commission, a number of reinforced concrete troughs have been made in substitution for the timber troughs previously used, the reason for the change being the rapidity with which slime accumulated on the wood troughs and the difficulty experienced in removing it. The concrete troughs are in units 10 ft. long by 2 ft. 4 in. wide by 10 in. deep, divided along the centre by a partition. Other tanks of reinforced concrete in the same establishment are used for the reception of growing fish of various kinds. Apart from their cleanliness, the concrete troughs and tanks have been found very convenient, and will last for an almost indefinite period.

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

PROGRESS OF THE ATELIER MOVEMENT IN GREAT BRITAIN.

A FRESH impetus is to be given to architectural expression in this country by the formation of two new Ateliers on the lines of the French Ecole des Beaux-Arts.

One of these is to be organised by University College, London, the other by the Architectural Association.*

This is one of the most important national decisions that has been made, and one which will have far-reaching effects. The decision of the authorities of University College is an admission of the fact which architects and builders have been urging for many years, i.e., that the training of those who have it in their power to beautify our surroundings, to build sensible and healthy homes for the people, is as important a matter as the training of young men for all other vital professions.

NEW ERA IN ARCHITECTURE.

It is also the sign of the dawn of a new era, when all who are linked together in the work of building, whether it be the architect, the builder, or the labourer, will work together with one object in view—the good of all men. For that, in brief, is the trend of the teaching which is now to be the chief method of this country. Although the Royal Academy confines its teaching to the work of the painter and sculptor, and is not at present to form an Atelier, the work of the three now established in London is to receive the attention and the aid of that august body.

In course of time the competitions will probably be judged by the President of the Academy and other Academicians, along with the patrons and sous-patrons of the Ateliers. Nor is this all, for the work of the Ateliers now being established can only lead to one thing. When it is recognised that these schools are a national asset, tending towards the erection of large and beautiful masses of architecture, proper homes for the people, and a broadening of the national mind through artistic surroundings, State aid for the movement is bound to follow.

The decision of University College may be looked upon as a triumph for the earlier organisation in London, which, inaugurated by and presided over by Mr. Arthur Davis, F.R.I.B.A., has done the work of preparing the soil for the splendid results we are now likely to see around us.

In France, architecture is considered one of the fine arts. This statement may seem obvious, but in this country we see so many architects claiming to be first of all professional or building men and considering the design of their building of secondary importance to professional and constructional considerations, so it cannot be too often repeated that the architect should be as he was in the olden days, primarily an artist and a creator. This fact is frequently lost sight of in this country, where the stress of competition and the necessity of making a livelihood has prevented the architect from receiving the same consideration and belonging to the same social status as men of other professions.

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* Since this article was written, the A.A. Atelier has made a successful start, with Mr. R. Atkinson, F.R.I.B.A., as Patron, and Mr. Bradshaw as Sous-Patron.

This fact has also given birth to an idea among the public that an architect is a gentleman something between a lawyer and a surveyor who spends his life in dealing with matters concerning party walls, ancient lights, leases and constructional problems, the question of the design and beauty of the building being quite secondary and unimportant.

Now in France the artist, whether he be painter, sculptor, architect or musician, is placed upon a very different footing, and the architectural student is proud of being considered an artist before anything else. He may hope later on to acquire knowledge in the other inseparable branches of his profession, but he nearly always looks at his career not from a professional but from an artistic point of view.

The Atelier movement in this country saw the light above a stable in the West End of London. There is something of the Gilbertian in the fact that a movement which had for its object the rearing of stately edifices, of beautiful buildings and well-planned towns, could have commenced in such surroundings. To those who go deeply into the psychology of the thing, however, it reveals the mentality, the determination, the tenacity, and the trust that what is right will prevail, of the men who were laying the foundation stones of the training of to-day.

The first step, to be precise, began in Wells Mews, in Wells Street, and as the pioneers received the moral and financial support of the Society of Architects, there was established a kind of club, with Mr. Davis as teaching patron, and a lieutenant sous-patron, in the person of M. Chaures, who is now looked upon as one of the leaders in the architectural movement in his own country.*

GUIDING SPIRIT.

The objective of the pioneers was to establish an Atelier, and, if it were a success, to form other Ateliers from time to time. As is well-known, there are numbers of excellent schools in the country where the elements of architecture are taught, but there were no opportunities, no encouragement, and no guiding spirit for the ambitious youngster who graduated into one or other of the offices of the country, hide-bound in many cases by convention and all the other drawbacks to the realisation of artistic expression and ideals. The Atelier was for advanced students only ; the fees were made very low, and to encourage the pupils who came, a student who won a competition was allowed to go scot free. This system has since been improved upon. Competitions are to be held from time to time under the auspices of the three Ateliers in London, thus giving a fillip to energy and ambition which will have a very material influence on the architecture of the future.

The influence of the Ateliers is already being shown in the winning of important Scholarships and Competitions.

The Society of Architects "Victory Scholarship" for 1921 was equally divided between two members of the first Atelier ; two members of this Atelier also won the Worshipful Company of Brewers' Competition. Members of the Architectural Association Atelier both won and were highly placed in the Rome Competition, which was gained in a former year by a member of the Liverpool School, which now controls an Atelier.

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* M. Chaures has now returned to England as Patron of the First (Society of Architects') Atelier.

THE MORAL.

The moral pointed to members of the Concrete Institute and workers in concrete is obvious and needs no laboured pointing.

In to-day's students of these Ateliers we have the great architects of to-morrow.

It is for the Institute to see that these young men receive that advice and attention in all matters connected with concrete which it is the duty and privilege of the Institute to bestow.

FANCY DRESS BALL.

The Students of the Royal Academy Ateliers are organising a Fancy Dress "Guy Fawkes" Ball, in aid of their funds, to take place at the R.I.B.A. Galleries on the night of November 4th next.

Tickets are 15s. each, but Students' Tickets at a specially reduced price may, by the kindness of the Dance Committee, be obtained by Students of the Institute, who should make early application to the Secretary of the Institute, 296 Vauxhall Bridge Road, S.W.1.

ANNUAL DINNER.

The Annual Dinner of the Concrete Institute will be held on Thursday, December 8th, 1921.

Particulars as to the venue, time, cost of tickets, etc., will be announced in due course, but in the meantime all members of the Institute are asked to book the date.

LIST OF MEETINGS TO BE HELD AT DENISON HOUSE. SESSION 1921-22.

October	20th (Thursday).	Finance and General Purposes Committee	5.30 p.m.
	27th (Thursday).	Council	5.30 p.m.
November	3rd (Thursday).	R.C. Practice Standing Committee	4.0 p.m.
		Science Standing Committee	5.30 p.m.
	10th (Thursday).	Literature Standing Committee	5.30 p.m.
	17th (Thursday).	Finance and General Purposes Committee.	5.30 p.m.
	24th (Thursday).	Council	5.30 p.m.
		Presidential Address by Mr. E. Fiander Etchells	7.30 p.m.
December	1st (Thursday).	R.C. Practice Standing Committee	4.0 p.m.
		Science Standing Committee	5.30 p.m.
	7th (Wednesday.)	Finance and General Purposes Committee.	5.30 p.m.
	8th (Thursday).	**Annual Dinner**	7.30 p.m.
	15th (Thursday).	Council	5.30 p.m.
		Paper by Mr. E. F. Sargeant on "The Preparation of Concrete Aggregates" and "Moving Forms".	7.30 p.m.
January	5th (Thursday).	R.C. Practice Standing Committee	4.0 p.m.
		Science Standing Committee	5.30 p.m.
	12th (Thursday).	Literature Standing Committee	5.30 p.m.
	19th (Thursday).	Finance and General Purposes Committee.	5.30 p.m.
	26th (Thursday).	Council	5.30 p.m.
		Paper by Mr. E. B. Moullin on "Capillary Canals in Concrete, and the Percolation of Water through them"	7.30 p.m.

February	2nd (Thursday).	R.C. Practice Standing Committee . .	4.0 p.m.
		Science Standing Committee . . .	5.30 p.m.
	9th (Thursday).	Literature Standing Committee . .	5.30 p.m.
	16th (Thursday).	Finance and General Purposes Committee.	5.30 p.m.
	23rd (Thursday).	Council	5.30 p.m.
		Paper by Mr. H. Kempton Dyson on "What is the use of the Modular Ratio?" .	7.30 p.m.
March	2nd (Thursday).	R.C. Practice Standing Committee . .	4.0 p.m.
		Science Standing Committee . . .	5.30 p.m.
	9th (Thursday).	Literature Standing Committee . .	5.30 p.m.
	16th (Thursday).	Finance and General Purposes Committee.	5.30 p.m.
	23rd (Thursday).	Council	5.30 p.m.
		Paper by Mr. S. F. Staples on "Floating Docks"	7.30 p.m.
April	6th (Thursday).	R.C. Practice Standing Committee . .	4.0 p.m.
		Science Standing Committee . . .	5.30 p.m.
	13th (Thursday).	Literature Standing Committee . .	5.30 p.m.
	20th (Thursday).	Finance and General Purposes Committee.	5.30 p.m.
	27th (Thursday).	Council	5.30 p.m.
		Paper by Mr. W. Noble Twelvetrees on "Reinforced Concrete Piers and Marine Works"	7.30 p.m.
May	4th (Thursday).	R.C. Practice Standing Committee . .	4.0 p.m.
		Science Standing Committee . . .	5.30 p.m.
	11th (Thursday).	Literature Standing Committee . .	5.30 p.m.
	18th (Thursday).	Finance and General Purposes Committee.	5.30 p.m.
	25th (Thursday).	Council	5.30 p.m.
June	8th (Thursday).	Finance and General Purposes Committee.	5.30 p.m.
	22nd (Thursday).	Council	5.30 p.m.
July	13th (Thursday).	Finance and General Purposes Committee.	5.30 p.m.
	27th (Thursday).	Council	5.30 p.m.

It is possible that some of our members are in need of assistants.

Enquiries and replies should be addressed to The Secretary, Concrete Institute, also to Prof. Ernest Wilson, Dean of the Engineering Faculty, University of London, King's College, Strand, W.C.2, and such replies should refer to this announcement in CONCRETE AND CONSTRUCTIONAL ENGINEERING.

By an oversight, in giving the Council for 1921–22 in the September issue, the following three names were omitted:—

Past Presidents :

PROFESSOR HENRY ADAMS, M.Inst.C.E.
MR. H. D. SEARLES-WOOD, V.P. R.I.B.A., F.R.San.I., etc.
MR. F. E. WENTWORTH SHEILDS, O.B.E., M.Inst.C.E., etc.

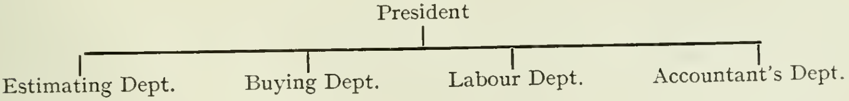
ORGANISATION OF A CONTRACTING FIRM.

By **OSCAR FABER**, O.B.E., D.Sc., etc.

Organisation, like philosophy, is one of those things which many people think they can afford to ignore, and in both cases, the only result is that though they have an organisation and a philosophy, it is probably a very bad one.

And yet there is this much to be said for the "practical man" who scoffs at organisation, that there has recently been a certain tendency to suppose that given sufficient organisation, other factors, such as personal character and a thorough knowledge of the art and trade of construction, for instance, coupled with and obtained through hard personal application, could be given less attention than previously. Perhaps this tendency has come from across the Atlantic and is a result of the intense enthusiasm for organisation which has lately appeared there. On entering the waiting-room of a small firm there, one would probably see displayed on the wall a diagram resembling a genealogical tree, something like the following :—

Diagram 1.



only carried much further, with the name of every individual duly displayed.

Let us at once agree that no amount of this sort of thing can produce an efficient firm unless all the *individuals* are all they should be.

And to an enormous extent, the character of the individuals will be determined by that of the chief, so much so, that though it would probably be an exaggeration to say that the character of the chief could be predicted with confidence from an examination of the office boy, yet there is something in it.

The chief will choose as his immediate assistants men who appeal to him, and who therefore will probably resemble him in many ways.

Thus, a scrupulously honourable chief will probably be so convinced that any form of taking or giving of bribes or secret commissions is, apart from other considerations, bad for business if one takes a reasonably long view, that he would not only be repelled by assistants who took a laxer or different view, but would also consider them a positive danger to his business. His assistants, in their turn, would feel the same towards *their* assistants, and so on down to the very bottom.

This principle applies not only to the *choice* of assistants, but also continues to act in everyday contact.

Every individual would meet with opposition to any unworthy course from his immediate chief if it were known that the head were opposed to such a course, which would not only act very powerfully in preventing the inception of such courses, but would also, in flagrant cases, cause individuals who take the other view to sever their connection with the firm at a very early date.

Let us agree, then, that the *character of the chief*, which practically determines that of every other member of the firm, is the first in importance.

Second in importance, I think I should put technical skill and experience. If the foreman on the job has not a full knowledge of the various trades, the reading of drawings and specifications, experience in the handling of men and of economical methods of laying out and organising his work, then even though his character be all it could be, on the other hand, and his relation to every other member of the firm be set out as clearly as a genealogical tree could convince him of his relation to his father; on the other, good, economical, and rapid work will not result, because he will not have the necessary data at hand when making decisions from minute to minute, and judging between good and bad.

The same applies, of course, to every other unit in the organisation.

Let us, then, place second in importance the *technical skill and experience of the individuals.*

We now come to the *relationship of individuals to one another.*

SYSTEM A.—I find, on reading much of the American literature on organisation, that they would separate the departments on the basis of *function*, as is indicated in *Diagram* 1.

This has many advantages, many of which are obvious.

Every individual will be continuously employed on one specialised kind of work, with the probable result that he will do it more easily and quickly. There will be no overlapping.

This system is probably good when applied to the running of a factory, but for a contracting firm the disadvantages are the following:—

1. There is divided responsibility for the success of any individual job. If it turns out to be financially a failure, it is practically impossible to say whether the cost was underestimated, the materials were bought too dear, the labour was too dear, etc., and whether, therefore, it is the estimating department, the buying department, the labour department, etc., which is to blame.

2. No one individual, save only the head of the firm, who is too busy, can go to a job and make a settlement of the various questions that arise.

Each department has to have its representative there. This involves a great waste of travelling time and expense. In fact, under this system, though many are all working hard, it by no means follows that the result is beneficial.

It also is much easier for a client to have only one individual to deal with, as in the system to be described.

SYSTEM B.—These very important disadvantages are overcome by the system now to be described. In this, where the firm is organised on the basis of *jobs* instead of function, there would be several departments each having a builder's manager as its head.

A new job would be allocated to one of these. Thereafter the manager of this department would be responsible for it from A to Z. He would prepare his own estimate, buy his own materials, organise his own labour, etc., etc.

This system gives clear and definite responsibility. If the head of the firm finds that department A is on the whole much less successful than the others, he can take steps to find out in what matter the fault lies, and, if necessary, can appoint a more competent manager. This would be difficult to ascertain on the other system, because an inefficient department would affect all jobs alike, and therefore would be hard to trace.

It is found, in practice, that there is no insuperable difficulty in a manager mastering the different branches, estimating, buying, labour control, etc., availing himself of any assistants and help he may require.

Under this system, the manager cannot divest himself of full responsibility for everything which affects the success of the job, and herein lies the keynote of the system, *responsibility*.

It follows, of course, that he must be given a pretty free hand in the organisation of his own department. Undoubtedly this system of organisation is very much better than the one first described.

System C.—In a large firm, it is possible to combine the advantages of both systems, combining the advantages of personal control and responsibility with that of specialised functions. This can be done as follows :—

In this case, a manager is made personally responsible for a number of jobs, the number depending on his skill and experience, and the size of the jobs—a good manager often having about five jobs, averaging about £100,000 each, less if they are bigger, and more if they are smaller.

As in system B, he alone has full control and full responsibility of all aspects affecting this job, correspondence, contracts, relations with clients, etc., estimating, buying, control of execution, etc. At the same time, there may be departments which specialize on special functions, such as buying timber, buying steel, estimating and checking prime costs, accounting, etc.

The important point to insist on is, however, that these departments shall not handle any work except at the desire of the manager responsible for the particular job, except in the case of the accountant's department, which must, of course, be responsible for seeing that the records of money transactions are properly kept and correlated, without, however, lessening the manager's control over these transactions.

In other words, with the exception of the accountant's department, the other "special function" departments exist only in a consultative capacity. An example will make this clear. Manager A, in charge of a big job, wants a lot of timber. In his experience, M, in charge of timber buying, is very unbusinesslike, and lets him in for charges which he considers avoidable. Consequently he prefers to buy his timber direct. On the other hand, he finds he can get valuable help from the estimating department, and therefore avails himself of this on frequent occasions, but at his own risk and without lessening his responsibility.

Manager B, on the other hand, might elect to let the timber buyer act for him, and may consider the estimating department unreliable and prefer to do his own.

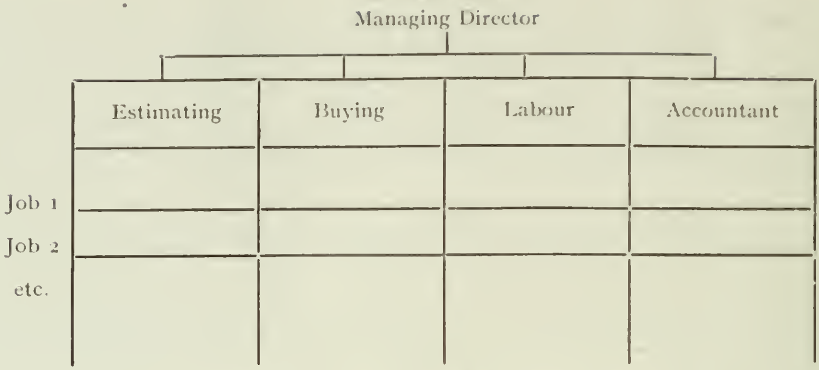
This arrangement, under which the manager of a job is given a free hand to accept or decline help (or hindrance) from the "special function" departments, is essential for many reasons.

First and foremost, because if you lessen the manager's control, you cannot hold him responsible.

Secondly, because the special function departments then become autocratic, and possibly inefficient, if work comes to them automatically, whether the manager likes it or not.

Those readers who find diagrams make these matters clearer, may find the following helpful, though they only express what meaning is put into them, and therefore a clear statement in words is necessary anyhow.

DIAGRAM 2.



System A.

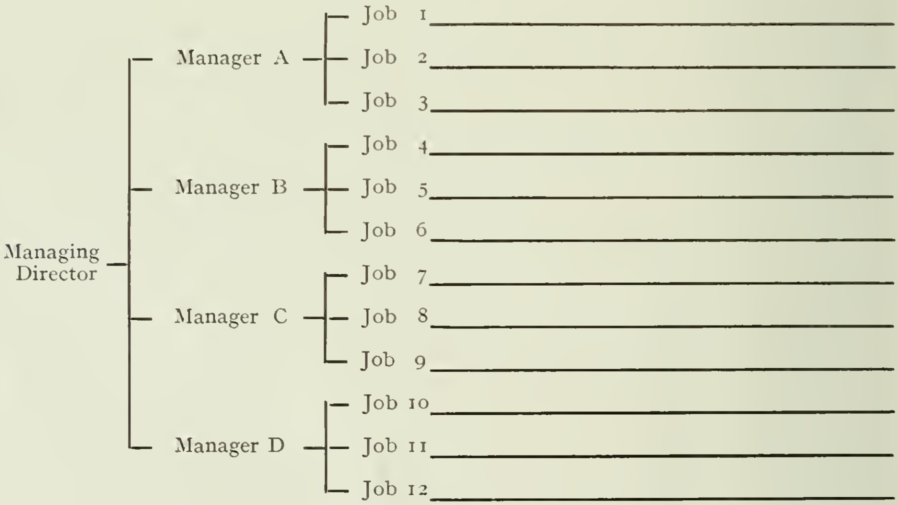
Organisation by " special function " departments, each of which has each job through its hands.

Advantages—Limited function of any individual should be labour saving.

Disadvantage—Divided responsibility for any job, divided control, difficulty of detecting inefficiency and faults.

VERTICAL ORGANISATION.

DIAGRAM 3.



System B.

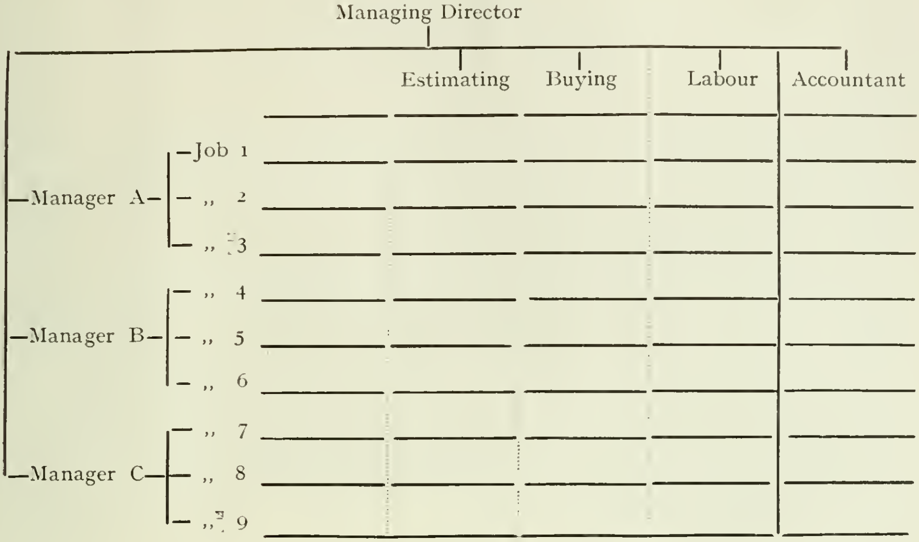
Organisation by managers in charge of definite jobs, for which they have to exercise *all* functions.

Advantages—Definite and clear responsibility, definite control, quick decisions and intimate knowledge of every fact about the job.

Disadvantage—Requires the individual to exercise many functions.

HORIZONTAL ORGANIZATION.

DIAGRAM 4.



System C.

Combines advantages of A and B.

Manager has full responsibility for certain jobs in all functions (except accountants in a limited degree). [Indicated by full horizontal lines.] Yet estimating, buying, labour, and other special function departments exist, but only handle any job at the option of its manager. [Indicated by dotted vertical lines.]

Advantages—Full responsibility and control, coupled with access to special function departments where desired.

In a large firm, this System C can be extended to practically any size without becoming unmanageable, and as the size increases, the advantages obtainable by the special function departments should increase.

Thus a very big firm may be able to buy all its timber at the source overseas and itself arrange for transport and import, and so be in a position to supply more cheaply than a manager could buy outside.

Similarly the estimating and prime cost checking department should have much more experience to draw conclusions from, and therefore should be able to offer more valuable help.

Yet the important feature of personal control and responsibility remains, provided the special function departments are kept optionable or consultative at the manager's discretion.

In a large firm, the managers may have work allotted to them depending somewhat on its character. A, having had special experience of harbours, docks, etc., would in the ordinary way handle any such job, B, having special experience of buildings, C of reinforced concrete, D of railways, etc.

The allocation of jobs among the managers would, however, also have regard to other considerations, such as not keeping one department too busy while another was too slack, giving the more successful one the most work until the manager felt unable to carry more with success.

Then, again, special knowledge of a district, and of a particular client, or the preference of a client for a particular manager, would all be important considerations.

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THE DECORATIVE TREATMENT OF CONCRETE.

E. GODFREY PAGE, A.R.I.B.A.

Continued from September Issue.

IN forming an alliance, however, each member can be sure of gaining more respect for the qualities of the other than separation can bring.

No architect of ability can see and handle the work done by a reinforced concrete specialist and note his truly amazing knowledge, and his freedom in the use of the most intricate scientific laws without being deeply impressed, the more so as to a greatly less difficult degree his life is spent among the same problems. And no engineer, when brought into technical contact with an architect trained in the long history of traditional art, can fail to feel that designing beautiful buildings is a life's work and requires a distinctly different capacity from that of the engineer pure and simple, or of the painter or sculptor. To appreciate this one has merely to look at a building of admitted beauty like St. Paul's to see that to a very large extent its beauty is derived from its multitude of mouldings. And it is a curious reflection that the only person in the world who cares a rush about mouldings, the only person to whom one moulding is not as good as another, is the architect. Were St. Paul's to be stripped of all its mouldings to-morrow the trained architect is the only person who could restore them : if it were done by the engineer or the sculptor every one would feel, without knowing why, that the building had been wrecked, as may be proved by looking at the few mouldings on the piers of any railway bridge or the pedestal of any statue erected without an architect's help.

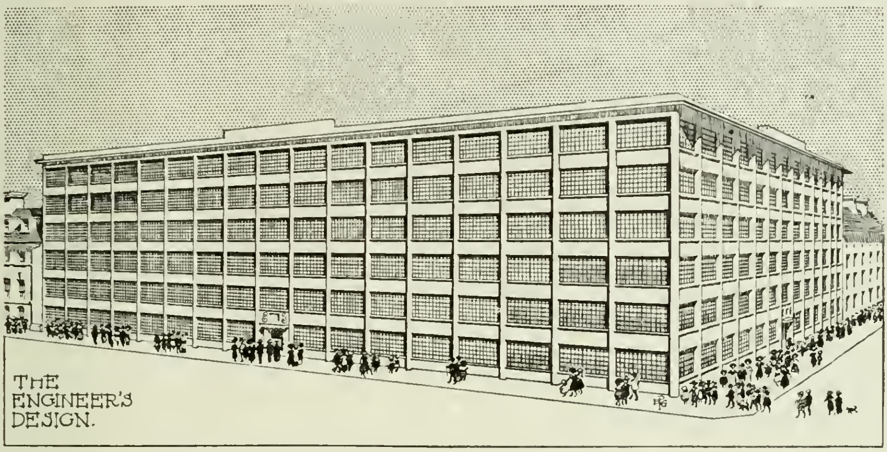
It is a regrettable fact, true beyond controversy, that such mouldings cause the acutest displeasure to the architect. He is not a *poseur* ; he knows that through his long study of historic style he is capable of communicating to others a sense of fitness and of beauty in the half-dozen lines of shadow, called mouldings, which he draws across a facade or round the drum of a dome ; and he knows that, were they to try, both engineer and sculptor would fail. Were he to attempt a piece of modelling or to express in his work the arm of eccentricity in a non-axially loaded stancheon he would fail as surely, and it is little to the purpose to remind him that the mouldings of the past, which to a large extent he copies, altering and adapting, were the work of masons who could barely read : the instinct they had is gone perhaps for ever, but his scholarship achieves the same result, and his presence and co-operation to that end were never more needed than they are to-day.

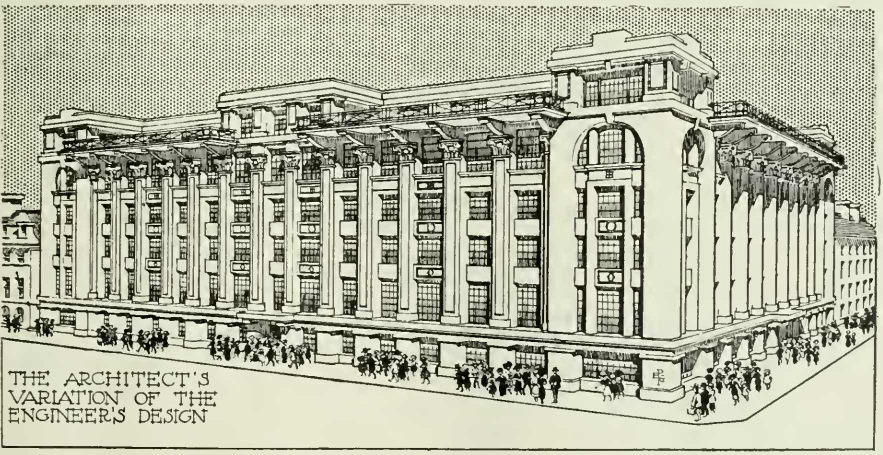
Assume, then, that it has been shown that this alliance between the architect and the engineer is to the advantage of the building and the public ; what are some of the principles along whose lines a great future can be predicted for Reinforced Concrete ?

First, the regard which he and the engineer acquire for each other will lead each to a policy of give and take. The architect will learn the leading principles of reinforced concrete design without becoming immersed in high-grade mathematical calculations where he is soon out of his depth. He will readily grasp the essential differences between the new material and the older ones with which he is familiar, and, while marvelling at the ease with which it accomplishes feats he would not dare in stone or brick, if he resolve sincerely to express its essentials and not to imitate theirs, he will be able to keep the great unchangeable laws of beauty : of symmetry, of massing, of variety, of rhythm in its strict technical sense, of the uses of monotony and contrast, steadily before him no less than those of strength of outline, of daintiness of detail and the interest of texture and colour. He will give way sometimes to his engineer collaborateur and change a strongly held opinion which he sees in a particular circumstance to be no longer tenable, and the engineer in turn, recognising that his colleague has something he has not, will give way, too, for the sake of a resultant beauty which it is outside his training to accomplish.

As an example, offered with humility yet with the courage of frankness, we will take a typical reinforced concrete building as it leaves the expert engineer's hand to-day and see where the help of the architect could improve it.

It is as bald a statement of a constructional problem as is St. John's chapel in the Tower, and perhaps some day it may acquire the same archæological interest. Meanwhile, let the most ardent reinforced concrete enthusiast ask himself whether a great city consisting solely of such structures would be anything less than a dismal nightmare. He knows in his heart that it would not ; that the moment he could get away for a brief respite from his work he would go where the painter and the architect go : to Rouen or Brussels, to Florence or Normandy. Yet all these places are packed with buildings which were as scientific and as utilitarian consistent with their designers' knowledge as is his. Suppose he had had an architect partner while he fashioned his design : is it certain that in making it more interesting he would have sacrificed any of his clients' real interests ? Let us see.

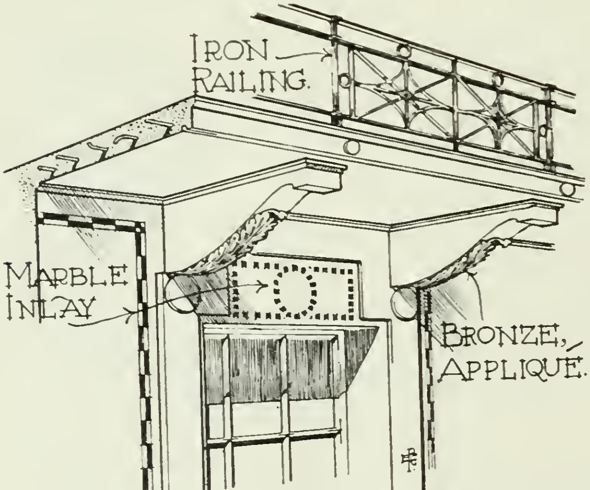

THE ENGINEER'S DESIGN.


THE ARCHITECT'S VARIATION OF THE ENGINEER'S DESIGN

It consists of a row of legs, and tier upon tier of beams of huge span. They are all just large enough, with the assistance of the tiny bars his clever brain has placed inside them, to do exactly the work they will be called upon to do; no less and, obviously, no more. Between them are tens of thousands of panes of glass all exactly alike in shape and size, and there are two doors, while the whole thing is one steady grey. Just as a sop to a conventionality, which he despises, (except when he is enjoying a holiday), he has put a moulding over each door and a bit of ornament which would make an artist wince, and has probably scratched a few lines across a portion to imitate the joints of stonework: they would not deceive a child in short frocks. The client is able to get the last ounce of daylight into the rooms, and his electric light bill and the amount of ground rent wasted on land covered by piers and walls is reduced to a minimum. The skyline (beloved by the painter when silhouetted against the western flame of cloud) is a line indeed: it was ruled! There is not a shadow over the whole façades more than two inches deep, the vertical and horizontal lines of pier and beam cross each other with the imagination of a chess-board; nothing is accentuated because everything is; nothing is kept back or pressed forward. It is scientific utilitarianism pure and simple, naked and unabashed.

But suppose the architect had spent a week or so with him on the preliminary sketches, not a conventional designer, but one with some knowledge, acquired from the engineer, of the motives which had guided him. Here are some of the many results which their joint effort might achieve, and before condemning them let the engineer ask if they make the building any less a reinforced concrete one than before.

These are some of the changes the architect has made. He has altered the skyline by setting back a portion of the top floor, and the space so lost he has made up by raising the angles a floor. He has arched the window heads at these angles because he learns that reinforced concrete bridges are often arched, and that arcuation is as legitimate as trabeation. He has made quite a fuss of these angle blocks, and by varying the window widths in them and in a central block he has given, by the contrast they present to the long monotony of the fenestration between them, importance to both, and obtained the quality known to the Venetian architects as rhythm. He has also obtained by a great cornice, cantilevered out by his partner in a way he would not dare to try in stone, a deep shadow, and has accentuated some of the piers and run them right through four floors, stopping the heads and sills of windows against them. Also, he has drawn a strong line across everything at the first-floor level, thereby accentuating the supporting character of the ground story. What has he lost either in accommodation or convenience, and what has he done which is false to the laws governing the simplest engineering design? Nothing. What has he gained? Everything worth having, unless all the beauty of Florence and Edinburgh, of Rouen and Venice, be an illusion.


IRON RAILING.
MARBLE INLAY
BRONZE, APPLIQUE.

A CANTILEVERED CORNICE.

TWO NEW METHODS OF CONCRETE COTTAGE CONSTRUCTION.

THE following notes and illustrations have been sent to us by Mr. James Houston, A.R.I.B.A., Kilbirnie.

The first of the two methods here described has for its object the elimination of moulds or blocks for wall construction. By this method, which has been adopted in the construction of a cottage at Kilbirnie, it is claimed that great economy can be effected. The walls of the house are formed on horizontal platforms a few feet above the ground and hinged as nearly as possible along the centre of gravity so that when the concrete had set each wall was turned over on its hinges into its exact position.

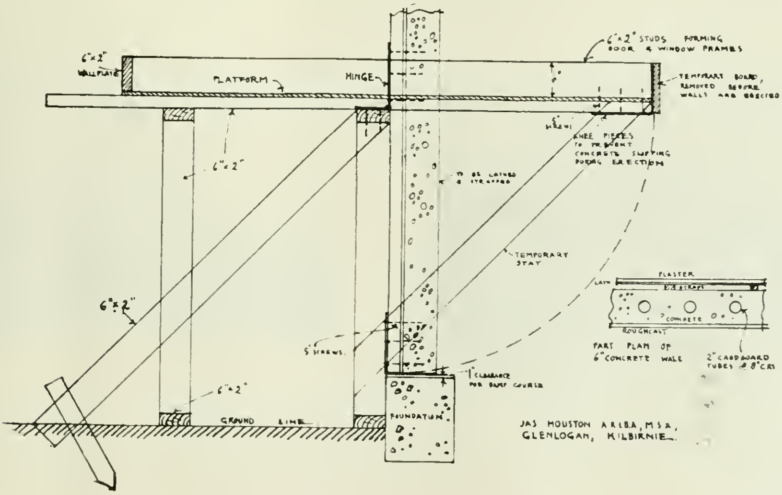
As this platform in its horizontal position is balanced in the middle, due allowance being made for door and window openings, it follows that the lower half of the wall, in descending, automatically raises the upper half. No force was required and no apparatus employed (other than rope). The platform was adjusted to its vertical position before the concrete was applied, and the wall naturally assumed its destined place with accuracy.

The door and window frames were laid down on the platform before the concrete was filled in, so that the house was then ready for its roof and internal finishings. The platforms were formed of the roof spars and boarding, so that the greater part of the material was on the site and ready for use. The time taken to erect the four walls, after the concrete had set, was only one and a half hours.

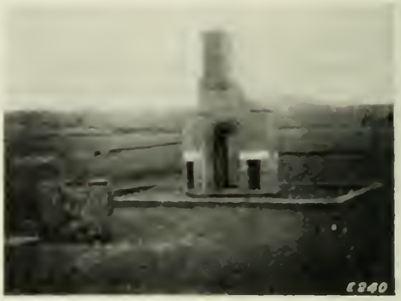
The greatest economy might have been achieved by placing a flat concrete roof on the top of the walls, but every attractive quality of the kind usually associated with cottage architecture would have been lost. Fortunately, there is nothing to prevent the concrete cottage from being roofed as any other cottage might be and from becoming as picturesque and delightful as we choose to make it.

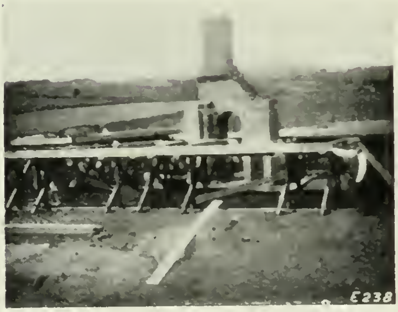
The diagram illustrates the construction in detail and shows the trestling and platforms in their preliminary and ultimate positions. Grooves were left in the concrete of the side and end walls where they meet at the corners of the building; these grooves were filled in from above with liquid cement, thus binding the walls together into one homogeneous and monolithic structure.

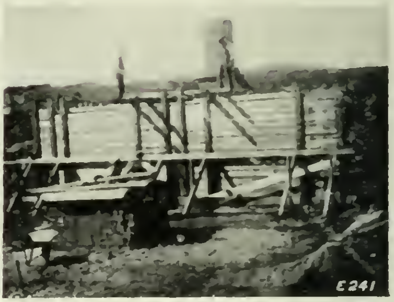
To some extent the method of construction will influence design, but local characteristics and traditional features need not be ignored, and, as with any other material, the quality of the design will depend upon the designer. One need not have any

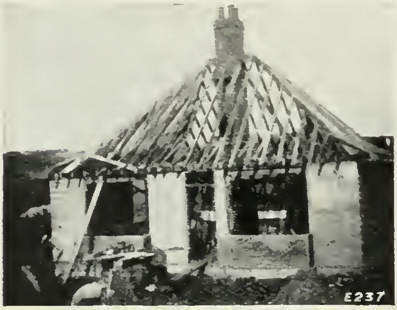

6"×2" WALLPLATE
PLATFORM
HINGE
6"×2" STUDS FORMING DOOR & WINDOW FRAMES
TEMPORARY BOARD, REMOVED BEFORE WALLS ARE ERECTED
5" SCREWS
KNEE PIECES TO PREVENT CONCRETE SLIPPING DURING ERECTION
6"×2"
TO BE LATHED & STRAPPED
TEMPORARY STAY
6"×2"
PLASTER
LATH
CONCRETE
ROUGHCAST
PART PLAN OF 6" CONCRETE WALL
2" CARDBOARD TUBES @ 8" CRS
5" SCREWS.
1" CLEARANCE FOR DAMP COURSE
6"×2"
GROUND LINE
FOUNDATION
JAS HOUSTON A.R.I.B.A., M.S.A., GLENLOGAN, KILBIRNIE.

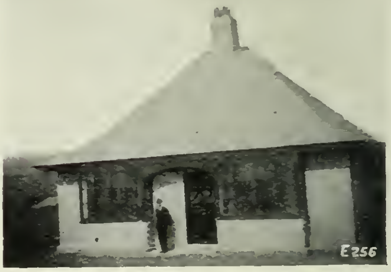
prepossession in favour of concrete, but the rough-cast dwelling is with us already and has a secure place in our affections; and the rough-cast dwelling may be of concrete as well as, or better than, of stone or brick.









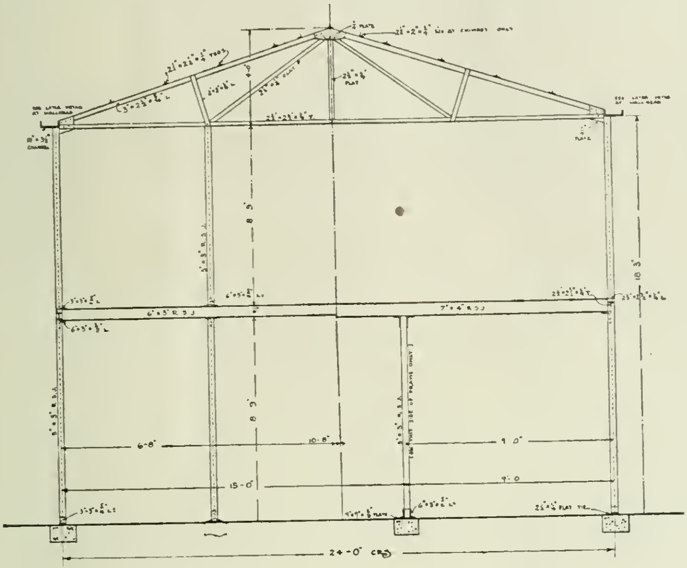


(This method has been patented by the late Mr. T. L. Watson, Patent No. 12,592, 1913.)

STEEL FRAME AND CONCRETE SLAB CONSTRUCTION FOR COTTAGES.

(Protected.)

The accompanying illustrations show a method of erecting cottages with steel frames and concrete slabs and has recently been applied to a housing scheme in Ayrshire.

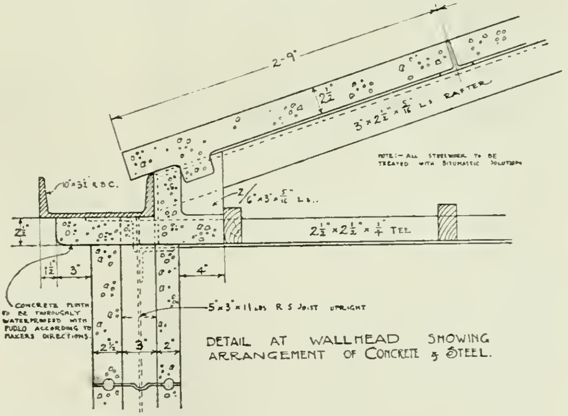


HALF END FRAME HALF INTERMEDIATE FRAME

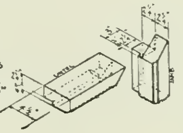
Brick Works and Steel Works are close to the site, but the Corporation of Glasgow having bought the former, concrete had to fill the breach, and steel having dropped fifty per cent. and being on the spot, had to form the other component.

The result has proved satisfactory; the total cost for each cottage averages £750. This is a remarkably low figure compared to the cost of brick houses erected in the district.

The drawings illustrate better than a written description the method of construction used. Attention is drawn, however, to the concrete raft and the concrete roof, both of which eliminate the extensive use of timber. The former, when reinforced, is specially suitable in mining areas where sinking ground is dangerous, and in conjunction with the steel frame, which is designed to take all the strain, is able to meet the reaction of underground workings. The latter is composed of nail-holding concrete slabs fixed between inverted tees and covered with a layer of nail-holding bitumen to receive tiles or slates. The slabs may be covered with natural rock asphalte treated with coloured bitumastic solution, or covered with any other materials compatible with practical efficiency, economy and æsthetic taste.


2-9"
2½"
3"×2½"×5/16" Ls RAFTER
NOTE:– ALL STEELWORK TO BE TREATED WITH BITUMASTIC SOLUTION
10"×3½" R.S.C.
2/6"×3"×5/16" Ls.
2½"
2½"×2½"×¼" TEE
1½" 3"
4"
CONCRETE PLINTH TO BE THOROUGHLY WATERPROOFED WITH PUDLO ACCORDING TO MAKERS DIRECTIONS.
5"×3"×11 lbs R S JOIST UPRIGHT
2½" 3" 2"

DETAIL AT WALLHEAD SHOWING ARRANGEMENT OF CONCRETE & STEEL.

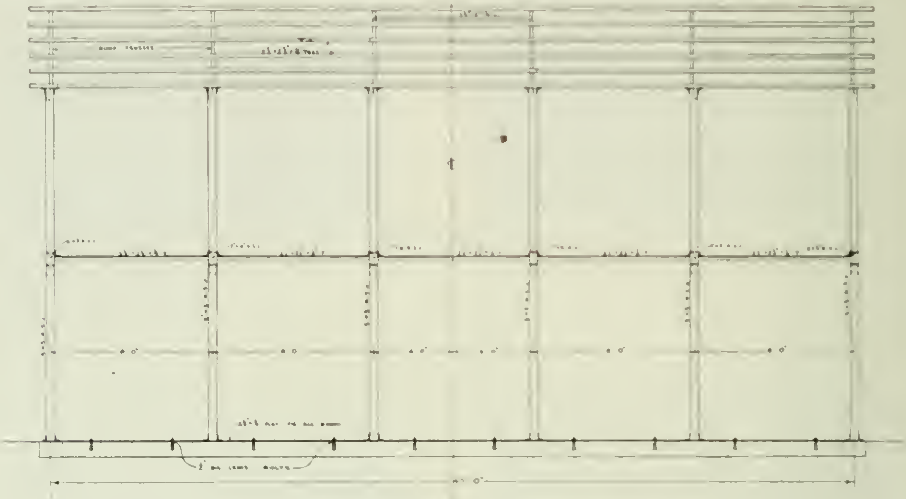


SKETCH OF MITRED & CHECKED JOININGS AT LINTELS OF OUTER DOOR FRAMES. WINDOW FRAMES TO BE MITRED & CHECKED IN THE SAME MANNER; NO "PLANTED" MOULDINGS OR FACINGS ON OUTSIDE WORK.

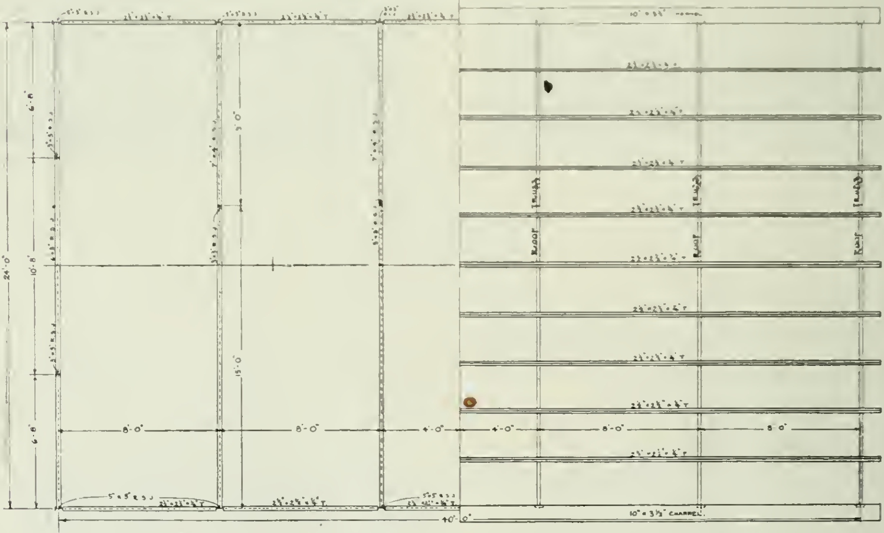
The maximum of standardisation in design consistent with certain practical and æsthetic standards has been effected and the slabs have been designed with the object of reducing the number to the minimum and increasing their size to the maximum compatible with economic duplication and handling.

The building of numerous brick flues is a heavy item in the initial cost, but in this case the flues have been deleted, except for the living room fire and the scullery boiler.

Speed is a great factor in economical building, but by ordinary methods, unless ample time is allowed for settlement, the result may be very damaging to the quality and stability of the building and no real economy thereby effected; but with this system, although the steel frame can be erected in one day and the outer walls in one week, there can be no lowering of quality or stability due to settlement since the steel frame is perfectly rigid immediately after erection and the walls, being only self supporting, require the minimum amount of time.



Side Elevation



Plan of First Floor

Plan of Roof

Mr. James Houston, A.R.I.B.A., Kilbirnie, is the inventor of this method of construction, which is protected by joint application for Patent No. 4981/21 by Messrs. David Colville & Sons, Ltd., Steel Manufacturers, Glasgow, and Mr. Houston. It is known as "Colville's System."

CEMENT NOTES.

By Our Special Contributor.

Slag for Concrete.

Any attempt to make use of a waste product of manufacture is worthy of support, because it benefits not only the industries producing and using the material, but the community at large. Blast-furnace slag is one of the commonest waste products, and if it can safely be employed as a concrete aggregate it is the duty of all concerned to foster its use. We accordingly welcome the report of the Commission appointed by the German Minister of Public Works to investigate the question of the suitability of blast-furnace slag for concrete.

It is well known that some slag has a pozzuolanic action when embodied in concrete, that is to say, it contains silica in a form which can combine with the lime set free by the cement on setting, and so add to the strength of the concrete; or, in other words, a concrete containing slag as the aggregate is in many cases stronger than a similar concrete containing gravel or crushed stone as the aggregate. On the other hand, all blast-furnace slag contains sulphur, and there are good reasons for believing that this sulphur is liable to cause retarded hardening of concrete, its subsequent disintegration and corrosion of steel reinforcement.

It has therefore never been possible to recommend blast-furnace slag as a concrete aggregate, and although it is admitted that large quantities have been used for this purpose, there is generally considered to be some risk of failure.

The Report in question, which is based on tests extending over five years, draws the conclusion that slag, if weathered for a few weeks before use, undergoes no change either due to internal chemical causes or external atmospheric influences, and it is also claimed that iron reinforcement is as durable in slag concrete as in the ordinary gravel or stone concrete.

In view of the amount of evidence supporting these conclusions they are entitled to careful consideration, but it needs to be emphasized that they apply only to blast-furnace slag that has been weathered for a few weeks, and it is not hypercritical to suggest that this qualification excludes old slag heaps, of which the crust has been weathered and partly decomposed by years of exposure while the interior is practically unweathered. Moreover, the tests given in the Report do not throw any light on the opinion held by some observers that slag concrete may remain intact for as long as twenty years and then show signs of expansion.

Labour Economy in Cement Handling.

American manufacturers are notorious for economy of labour, and the cement industry is no exception in this respect; but the degree to which labour economy is practised in the United States in the packing of cement needs to be seen to be fully appreciated.

The cement is mechanically extracted from silos and fed into automatic machines which fill the bags with the required weight of cement and discharge them by means of a conveyor at the door of, or even into, a railway wagon. The machines are capable of being operated by youths, and the labour employed in this department is no more than a fifth of that employed at an English works where the filling of sacks is done by hand.

A few English cement factories have been employing automatic sack-filling machines for some years, but not with the same capacity for labour saving; other English manufacturers are now introducing the type of machine generally adopted in America. The open warehouses which constitute the cement storage equipment of the older English works do not lend themselves so readily to automatic packing as do the concrete-silos which are typical of modern works, but this is a disadvantage that is being overcome by engineering ingenuity.

The American practice is, however, considerably facilitated by the use of the small bags of 94 lb. capacity which are standard in that country, the unit for selling purposes still being the "barrel" of 376 lb. (4 bags)—a relic of the times when the American Continent depended entirely on English cement imported in barrels of that capacity. Such bags are more readily dealt with by mechanical conveyors, while it is possible for eight of them (totalling 752 lb. in weight) to be wheeled by a man on a single sack trolley, compared with the single sack of 204 lbs. which is the usual load for a sack trolley in this country.

The sack of 94 lb. capacity commends itself to the engineer as a cubic foot unit for concrete mixing purposes, and it is generally a more acceptable package for the merchant and the user. Unfortunately, such a sack—made of cotton material—does not remove the irritating source of dispute between manufacturer and customer as to damaged and missing sacks, because, although unlike English sacks it is useless as a door-mat, it is found to have various domestic uses.

A further development has, however, taken place in America in the distribution of cement, viz. in bulk without sacks. This is done in closed railway wagons, of which the doors are boarded up to a sufficient height at the works, and the cement is filled into the wagons by gravity from a convenient conveyor. Such an arrangement reduces the cost of loading the cement and saves altogether the cost of sack hire, the cost of return carriage on empty sacks, and all the incidental costs connected with sacks. Where a consumer expects to use 1,000 tons of cement or more in the neighbourhood of a railway siding, it pays him to erect a storage bin and mechanical elevator to take the bulk cement from the railway truck direct to store, but where the quantity of cement to be unloaded does not warrant the expenditure on mechanical plant, the cement can be trimmed by shovels into a warehouse alongside the railway truck.

The mechanical arrangement for unloading cement in bulk can readily be combined with a similar device for unloading and storing of aggregate, and where this is done, it then often becomes a cheap and convenient procedure to measure from the cement and aggregate bins the definite quantities required for each batch of concrete, and transport the materials together in a small wagon or other convenient receptacle, to the concrete mixer.

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CORRESPONDENCE.

Under this heading we invite correspondence.

Concrete Roads.

Following upon an article published in these pages in our July issue, page 445, we have received an interesting letter from America regarding the quantity of water used by Mr. Edwards in the Bath Road described. In view of the importance of the subject, we are publishing this letter from our American correspondent, together with Mr. Edwards' reply. We invite the experience of surveyors on this important point.—Ed.

To the Editor of Concrete and Constructional Engineering.

Gentlemen—In your issue for July, 1921, we were interested in the article on page 445 entitled "Reinforced Concrete Roads" by D. Edwards, City Engineer of Bath.

In Mr. Edwards' article he emphasises the fact that a very dry consistency of concrete was used, and he states in two places that the quantity of water used in mixing should not exceed 10¼ gallons to the cubic yard of concrete when the aggregate is dry.

This quantity of water is so much at variance with practice in the United States that we were inspired to make inquiry regarding it. Mr. Edwards states that his mixture was composed of the following aggregates: 3 parts of limestone, 1½ inch to ¼ inch gauge; 1 part ¼ inch gauge limestone; 1 part sand; and 1 part of cement. These proportions are practically the equivalent of very widely used concrete pavement proportions in the United States; namely, 3 parts of stone, 2 parts of sand (or sand and screenings mixed), and 1 part of cement.

The minimum quantity of water which we would consider advisable for such proportions would be approximately 36 American gallons or 30 British imperial gallons. We believe the British imperial gallon to be approximately equal to 1·2 American gallons. Unless we have misread Mr. Edwards' statements in some way, it is evident that he is using approximately 12·3 American gallons to the cubic yard of concrete, or practically one-third of the amount considered advisable in America.

If our interpretation of Mr. Edwards' statement is correct, it would appear that he is not using a sufficient amount of water to develop the maximum strength of his concrete. The amount of water which he mentions is about equivalent to that used in this country for only the very driest concrete mixtures, such as are used for concrete block construction which is moulded by machinery. The dryness of the consistency for concrete blocks is made necessary by the fact that the blocks must be removed from the machine immediately after moulding, and the deficiency in moisture has to be supplied during the curing period by means of storage in saturated steam chambers, or by storing the blocks in water or under spray as soon as they have sufficiently hardened to permit such treatment.

It will be noted that Mr. Abrams, in dealing with the question of "How the Quantity of Mixing Water Affects the Strength of Concrete," * maintains that for a mixture of 1 part cement, 2 parts sand and 3 parts stone the minimum quantity of water recommended is 5¾ gallons per sack of cement. A sack of cement is 94 pounds net, or very closely 1 cubic foot by volume. By referring to Abrams' Tables for the 1 : 2 : 3 mixture, using an aggregate having a maximum size of 1½ inches, you will note that the quantity of cement for a cubic yard of concrete is 1·61 barrels. This is equivalent to 6·24 sacks, requiring a minimum of 5¾ gallons per sack, or a total of 35·9 American gallons per cubic yard.

As a matter of actual practice, probably in the average consistency upon the majority of the concrete roads constructed in America the amount of water used is in excess of the maximum amount mentioned in the table. This practice, of course, is discouraged by the engineers and inspectors, but it is probable on most contracts the amount of mixing water used is closer to the maximum stated in the circular than it is to the minimum.

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* See this issue of Concrete and Constructional Engineering, page 664.

We have watched with much interest the development of the use of concrete pavements in England as occasionally reported in CONCRETE AND CONSTRUCTIONAL ENGINEERING, and feel confident that the use of this material will continue to develop as its merits are recognised by the public.

Yours truly,
C. R. EGE.
Manager, Highways Bureau, Portland Cement Association, Chicago.

To the Editor CONCRETE AND CONSTRUCTIONAL ENGINEERING.

DEAR SIR—I have been particularly interested in Mr. C. R. Ege's remarks regarding the quantity of water used in connection with concrete road making, and am pleased to say that he has not misread the figures contained in the short article which appeared in your journal.

Experience in laying concrete roads has taught me to minimise the quantity of water to the fullest possible extent, and with ordinary dry material 10¼ gallons of added water per cubic yard was the maximum used in the construction of the successful roads which have been constructed at Bath.

I gave this work my personal supervision, and have no hesitation in stating that for success, and to avoid possible disintegration of the road surface, as little water as possible should be used.

The dense concrete provides the larger aggregate to be uniformly distributed, so that the weight of heavy traffic and the rolling motion is taken on the surface, and consequently the tendency to disintegration reduced to a minimum.

The importance of this outweighs the suggestion that the quantity of water used does not allow the full development of the strength of the concrete.

In the use of wet concrete, the larger aggregate naturally deposits at a bottom layer, leaving cement (in a small proportion) and sand on the top layer as a wearing surface, which is generally the cause for the disintegration one hears so much of in connection with concrete roads.

It might be useful to add that during the period of setting (four weeks), the whole surface was covered with suitable material to retain moisture, and which was watered daily.

There is no need for me to say more than that under similar circumstances I should carry out any future work in accordance with my previous convictions and experience.

Thanking you for the courtesy you have extended in the matter,

I remain,
Yours faithfully,
D. EDWARDS,
City Surveyor.

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

NORTH CIRCULAR ROAD, WILLESDEN.

DEAR SIR,—In your issue for September you have an unsigned article on the North Circular Road, Willesden, Section No. 1, and I shall be glad if you will publish this letter, as there are certain statements in the article which are not correct.

The bottom paragraph on page 572 states that "the concrete is much sloppier than that used on the Southwark roads and under the circumstances it is probably necessary." The word "sloppier" is not an appropriate one to use, as it conveys a wrong impression and I entirely disagree with this. The concrete at Willesden may have been mixed with a little more water than at Southwark, but I should think the difference is very small. The Willesden concrete is mixed with a concrete mixer and turned over very many times, whereas had the concrete been mixed by hand instead of by machinery, in my opinion, it would have required much more water to bring it to the same consistency. The bottom part was composed of 5 parts 2 in. to ⅜ in. ballast, 2½ parts of sand and one part of cement, and this was mixed with 11·5 gallons of water to the cube yard. The top coat consists of three parts ⅜ in. crushed river ballast, one part of sand and one part of cement. This was mixed with 18½ to 19 gallons of water to the cube yard, temperature 98 in the shade, all aggregates dry. The Walker-Weston reinforcement can be laid with either a dry or wet concrete; there is nothing that I know of in this reinforcement to prevent this being done, and I think this paragraph is very misleading.

The quality of the concrete is shown by the tests for absorption. Blocks about 1 ft. square are cut out of the road, and after being thoroughly dried are immersed for 48 hours in water, and the percentage increase in weight is shown as follows:

1, 2·284; 2, 3·0; 3, 2·95; 4, 1·76; 5, 3·3.

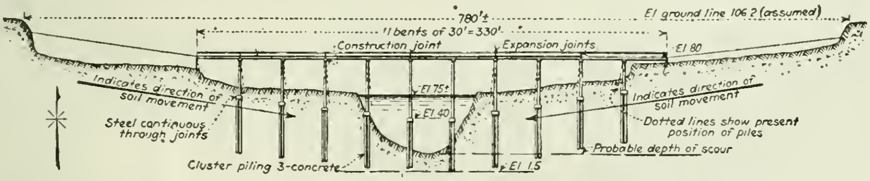
The thickness of the concrete is 8 in. and not 8½ in. as stated. It was only for the first three or four days that this was laid 8½ in. and the record of length completed up to date has been 90 ft. run per day.

I think that the tests of absorption as given above will prove convincing to the Engineer as to the homogeneity of the concrete.

Faithfully yours,
(Signed) F. WILKINSON,
Engineer to the Willesden District Council.

MEMORANDUM.

Failure of a Concrete Pile Bridge due to Slipping Foundations.—A recent number of the *Engineering News Record* gives an interesting account of the progressive failure of a concrete pile bridge due to the deepening of the channel of an undercutting stream. The bridge is over New River in Southern California, and was built in 1918 on the line of the State Highway from San Diego to Imperial Valley. It is of the reinforced-concrete trestle type, containing 11 bents of 30 ft. span. The movement of the bents is indicated in the accompanying drawing. Three of the eleven bents are in the present stream channel.


780'±
El ground line 106 2 (assumed)
11 bents of 30'=330'
Construction joint
Expansion joints
El 80
El 75±
El 40
Indicates direction of soil movement
Indicates direction of soil movement
Steel continuous through joints
Dotted lines show present position of piles
Probable depth of scour
Cluster piling 3-concrete
El 1.5

Reinforced-Concrete Trestle over New River in Imperial Valley showing Movement of Bents.

Using an assumed datum of El. 100 the bridge floor is at El. 80. Reinforced-concrete piles were driven in two clusters at each bent to E. 1.5 for the central bents, the penetration being slightly decreased toward the abutments, and a concrete cap poured over them at El. 40 for central bents and stepped up, as shown in the sketch, to the abutments. On these caps the two posts for the superstructure were cast in place. Both footing and posts were tied by reinforcement into the caps. The piles for the bridge were driven with great difficulty, water jets being used in all of them. No change in the character of the ground was indicated for the depth to which the piles were driven. In fact, wells driven in the vicinity indicate a silt loam for a depth of several hundred feet.

About the beginning of last year (1920) it was noted that the centre of the bridge was apparently moving downstream. This movement was slight but sufficient to be noted by the eye, without the aid of instruments. Upon examination it was found that small cracks were developing in the abutments and posts at the end bents near the ground line and between the caps and the girders.

In August, 1920, the conditions had become more serious. A more recent inspection shows that the movement is continuing.

From the character of the failure noted, it would appear that there is a movement of the ground from the extreme banks of the channel on each side toward the middle of the stream, this movement being permitted through the release of pressure due to the cutting of the river. This movement may have been assisted by the numerous earthquakes which have occurred in the valley during the past year.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Useful Engineers' Constants for the Slide Rule. By J. A. Burns.

Paper, 2s. nett. 78 pp. Crown 8vo. London: Percival Marshall & Co.

The fact that this is the third edition of this book seems to prove that it is found to be of value to some engineers. It consists for the most part of an explanation of how to set the slide rule to perform a number of operations involved in lations covering a wide range from contampressors to pendulums. It equivaleiso a quite good list of metric cannot see in' useful constants. We book can be of as respect the present the ordinary engineer's assistance as [illegible] book. which appears to contain all the principal information and a very great deal besides.

On general principles we are quite opposed to teaching engineers to make calculations by telling them to set the scale to a certain number and another scale to another number and read off somewhere else. We prefer to teach them how to use the slide rule in a general way and also to train them so that they will understand the various formulæ which are employed in practical work.

One of the great dangers in all books which merely give a summarised treatment and a whole lot of formulæ torn from their contexts is that people will be inclined to use them who do not understand them, and we cannot see that a book which gives rules for a method of setting the slide rule to make various calculations is free from this danger.

Mr. Burns states in the preface: "The book is intended for the use of commercial engineers and others whose business demands a system of rapid calculation. To the specialist, who has frequently to make calculations of a similar nature, the value of Constants becomes apparent, and the author shows how these are obtained in several cases which have come into his own special work."

Our opinion is that anybody who understands enough of a subject to be entrusted with calculations upon it and who knows enough of a slide rule to be entrusted to use it, will make his calculations without following the directions set out in this book and others of its kind.

Practical Geometry for Builders and Architects. By J. E. Poynter.

409 pp. Demy 8vo. Price 15s. net. London. Chapman & Hall, Ltd.

This book is one of the series of text-books planned under the weird title of "Directly-Useful" by the late W. J. Lineham, M.I.C.E., and the present volume resembles its predecessors in the series in its clear diagrams and good printing.

An idea of the scope of the book can be obtained from the chapter headings, which are as follows:—Scales; Angles and Angle Measurement; Construction of Triangles; Plane Rectilinear Figures; Similar Rectilinear Figures; The Circle; Loci; Spiral Curves; Plane Curves; Geometry as a basis of ornamentation; Brick and Masonry Arches; Solid Geometry; Sections of Solids; Intersection of Inclined and Horizontal Mouldings; Developments; Interpenetration of Solids; Roof Surfaces and Bevels; Oblique cuts in Carpentry and Joinery; Projection of Shadows; Pictorial Projection; Horizontal Projection; Graphic Statics.

Mr. Poynter has produced a book upon somewhat conventional lines which will probably be popular with those building students who are willing to pay fifteen shillings for a text-book upon practical geometry, and the criticism which we have to give later is not directed at all against the author's execution of his book but against the scheme of the book, which is a fair reflection of the method of training now becoming almost standardised in our technical schools and, we believe, encouraged by the technical educational inspectors.

The aim of a book of this kind may either be purely educational in the sense of presenting the principles of a subject in a manner which develops a perspective grasp of the subject as a whole, or else it may be for the purpose of teaching draughtsmen how to make their drawings; the present book, in common with all of its type, attempts to do both things at once and the result is not very successful. There is a curious mixture of principles with what may be termed "drawing dodges." We believe that the greatest need at the present time is to train students in the principles of their science and to present these principles in a clear and interesting manner, and that there are great dangers in making the books too "directly-useful."

To illustrate what we mean we will refer to Chapter IV on Plane Rectilinear Figures in which we have a number of geometrical constructions given, and some worked problems which appear to bear no relation to them—such as constructions for cutting the strongest and stiffest beams from a log of wood. In our opinion, if the problem of the beams cut from a log is given at all (even assuming it to have any practical value) it should be accompanied by some explanation of the principles involved and not merely presented as a bald construction.

The chapter on Graphic Statics is necessarily very short, so short that we think that it would be better to leave it out altogether; the subject is one of fundamental importance to builders and architects, and cannot possibly be dealt with in thirty pages. We have the same opinion about the chapter on Brick and Masonry Arches.

MEMORANDUM.

New Design Data for Cement Slabs.—The method of pouring cement slabs by shooting the mixture of sand and cement into the forms under pressure has recently developed to a point, says the *American Architect*, where accurate design data have been obtained for figuring the strength of such slabs.

Tests have been conducted under the supervision of Mr. M. O. Fuller, Adjunct Professor of Civil Engineering at Lehigh University, and George E. Strehan, Consulting Engineer. The materials entering into the slabs used in these tests were such as are ordinarily met with on good construction work. The slabs were reinforced, and the "shooting" was done by means of a Cement Gun.

The exact amount of water for proper hydration of the cement was automatically controlled. The slabs were shot into the forms in one operation, the air pressure 20–22 lb. per sq. in., and the water pressure 50–60 lb. per sq. in.

All slabs were loaded without interruption to complete rupture, except two. Pig iron was used and applied in increments of approximately 500 lb. by hand in order to simulate ordinary handling of one-man weights in the average factory or warehouse.

In the case of the two exceptions above referred to one of the slabs (3 ft. 9 in. wide with span of 6 ft. and 2½ in. thick, with 11·33 per cent. of reinforcement) was loaded to 368 lb. per sq. ft., the deflection at that time being $\frac{7}{16}$ in. This load was left on the slab for seven days, at which time the deflection had increased to nearly $\frac{5}{8}$ in. The loading of the slab was then resumed and it broke under a load equivalent to 870 lb. per sq. ft. The peculiarity noted was that the deflection curve on the second loading was parallel to the first loading.

The other slab (4 ft. wide with clear span of 8 ft. 3½ in. thick, with 1·69 per cent. of reinforcement) was loaded to 440 lb. per sq. ft. This was practically the yield point of the steel. Microscopic cracks appeared at the centre and under both rollers. An examination of this slab after 185 days showed the deflection had increased to $2\frac{1}{16}$ in.; that the cracks had not increased; and that no further cracks had appeared. The effective depth of this slab was 2½ in.

It is stated that these tests definitely showed that a mixture of one part Portland cement to three parts sand applied in this way in slabs can be assumed to have a factor of safety of 4 when stressed to 1,500 lb. per sq. in. A 1 : 2½ mixture has a factor of safety of 4 when stressed to 1,800 lb. Actually, these factors of safety are 4·16 and 4·85 respectively.

Translated into floor thickness, these values show extremely interesting facts. For instance, such floors may be constructed of only one-half the thickness of concrete floors, to support the same load, thus effecting great economy in labour and materials, in the construction of floors, roofs and side walls.

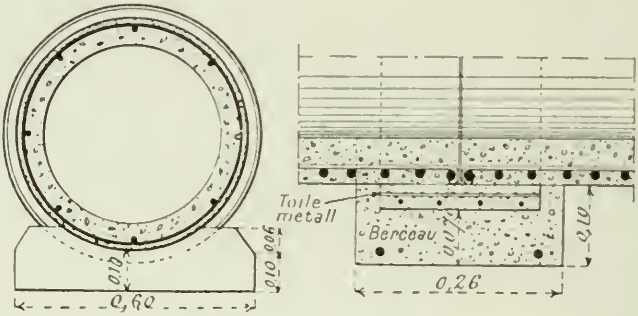
Further, the reduction of dead load due to the decrease in floor weights, is transmitted to the frame and through it to the foundations, both of which may be designed for a largely reduced dead load.

SOME ABSTRACTS FROM THE FOREIGN PRESS.

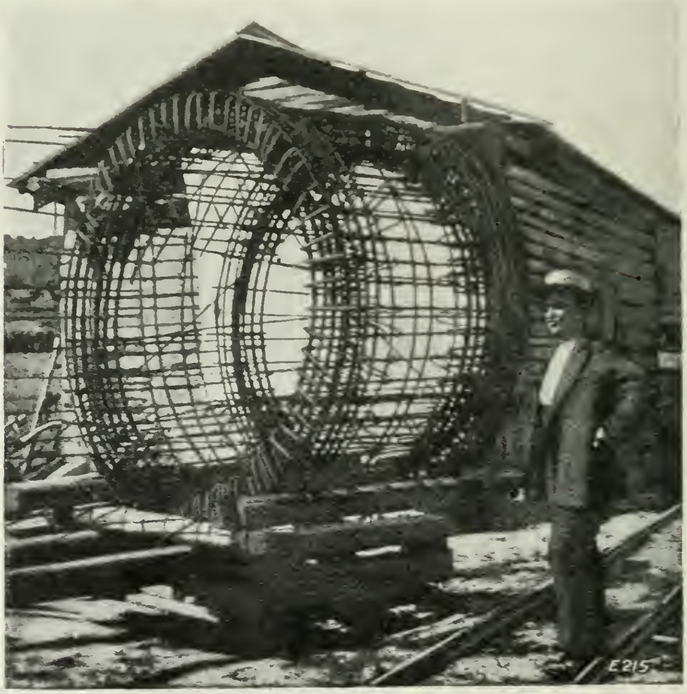
CONCRETE SIPHONS.

One of the largest siphons said to be in existence is that of the Palazzo S. Gervazio in connection with the Pouilles Aqueduct in Italy. This siphon is 4,840 yds. in length, whilst another similar siphon at Loccone is 1,210 yds. long and has a maximum rise of 60 yds. where it crosses the Calcarai—a torrential river 522 yds. wide. Each of these siphons is built in duplicate, the pipes being 6 ft. diameter and designed for withstanding water at a constant head of 100 ft. and flowing at the rate of more than 6,000 cub. yds. per second.

The concrete used for these enormous pipes is a mixture of 1 part of cement, 1½ parts of sand and 2 parts of small gravel. A richer mixture was avoided as it would have shrunk too much. The inside of the pipes was finished with a mixture of equal parts of cement and fine sand.



Details of one of the Joints.



Showing Reinforcement Concrete Siphons.

The pipes were constructed of a simple type of reinforcement, the greater part of the light rods being arranged horizontally and held in place by coils of wire—each coil of the same diameter as the pipe—placed at each end of each section of pipe, a single wire extending spirally the whole length of each section. The coils were held in position by a spiral wire.

The thickness of the pipes was varied according to the pressure of the water passing through them. The concrete was applied by surrounding the pipe with a suitable mould and rotating it on trunnions whilst the concrete was injected. This centrifugal method of application (the Vianini process) ensures a particularly compact concrete and enables the pipe to be cooled internally with bitumen at a nominal extra cost.

Each pipe rests on a concrete bed 8 ft. wide shaped to fit it, and the vertical air pipes are carried in triangular structures, of which the base forms an inspection chamber.

The joints were merely butted together and surrounded by a short length of pipe cast *in situ* as shown in one of the accompanying illustrations.—*Le Génie Civil.*

IMPROVEMENTS IN CONCRETE SHIPS.

At a recent meeting of the German Concrete Association in Berlin, Herr Weidert stated that by far the best method of constructing concrete vessels was the monolithic, i.e., casting the concrete between two sets of shutters. Concrete vessels are relatively much lighter than formerly, and their displacement is now only 3,850 cu. in. per cu. yd. as compared with 6,400 cu. in. two years ago.

The difficulty of ascertaining how closely the designers of concrete ships should follow the lines of ordinary shipbuilders is very great and requires much more attention that it has yet received. The difference in the requirements of ships and land structures is very great, yet notwithstanding this, there is a saving of 60 per cent. in the use of concrete for shipbuilding.

The use and value of light and porous concrete appears to have been seriously over-estimated and the present tendency is to produce a well graded concrete of specially good quality, regardless of its specific gravity.

Hammers operated by compressed air have proved very useful in tamping the concrete.—*Beton u. Eisen.*

NEW CONCRETE BRIDGES IN TCHECO-SLOVAKIA.

The budget for the Slovakia State highway bridges allows for the expenditure of 13,000,000 crowns, but the costs of construction have risen so rapidly that special arrangements have had to be made with the contractors. Yet notwithstanding the difficulties, the fact that forty bridges have been constructed is sufficient to show the strength of the young Republic. From these bridges, we select the following :

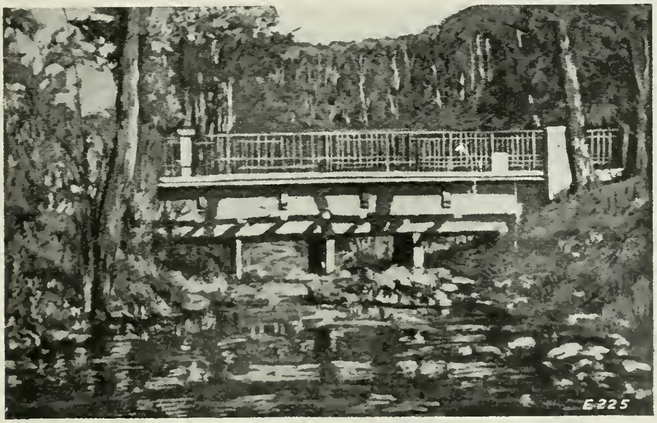


Fig. 1. Bridge over the Punkva.

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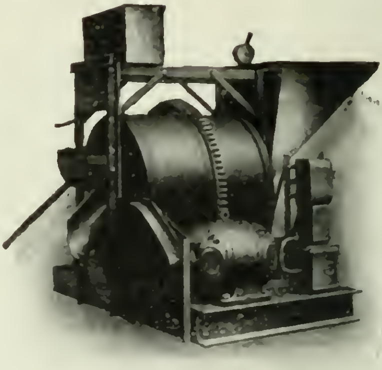

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A small bridge (*Fig.* 1) of 37 ft. span on the Punkva near the celebrated Machocha Chasm is chiefly of interest to those tourists who require to use it. It cost 150,000 crowns.

The state bridge over the Berounka at Lahovice (*Fig.* 2) consists of three arches each of 133 ft. span built of reinforced concrete on the Hennebique system. It was designed prior to the war and the original estimate of cost was 560,000 crowns.

The bridge over the Radbuza at Stankov (*Fig.* 3) has three arches, the two outer ones each having a span of 43 ft. and the middle one a span of 106 ft. It is the only bridge in the Republic in which the roadway is suspended from two parallel arches. It cost 1,250,000 crowns.—*Revue du Béton Armé.*

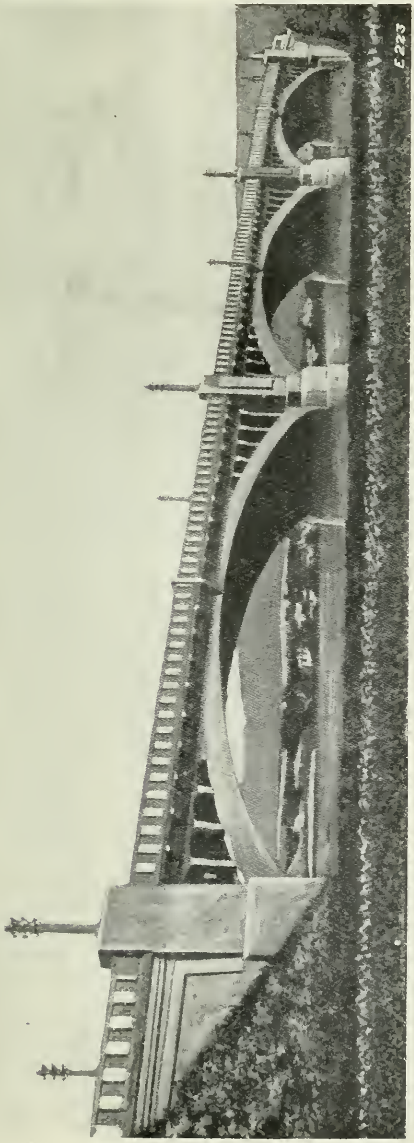

Fig. 2. Bridge over the Berounka.

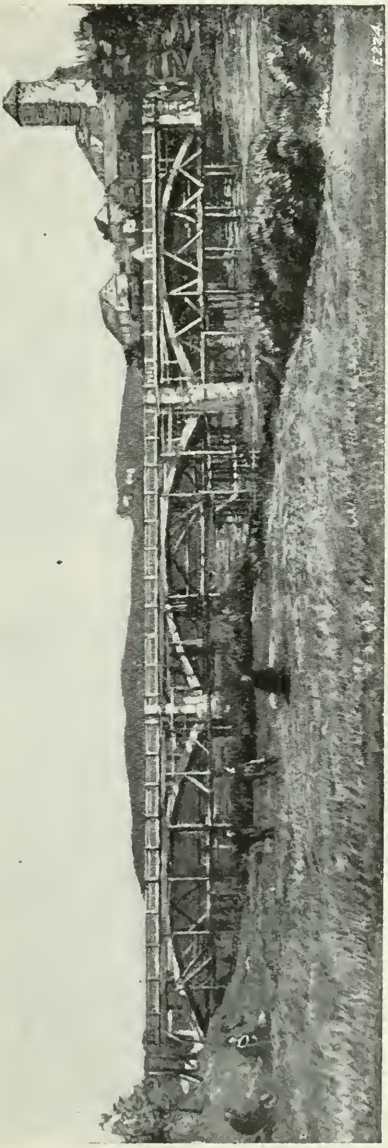

Fig. 3. Bridge over the Radbuza.

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WHERE electric power is not available, or for special reasons petrol or oil fuel is undesirable, the steam-driven "Victoria" Concrete Mixer forms a very compact and self-contained equipment. The model illustrated here is capable of delivering perfectly mixed batches in quantities varying between 54 and 3½ cubic feet as required.

The long arm saves much time and labour in handling, and possesses a delivery radius sufficient to meet all practical road building requirements.

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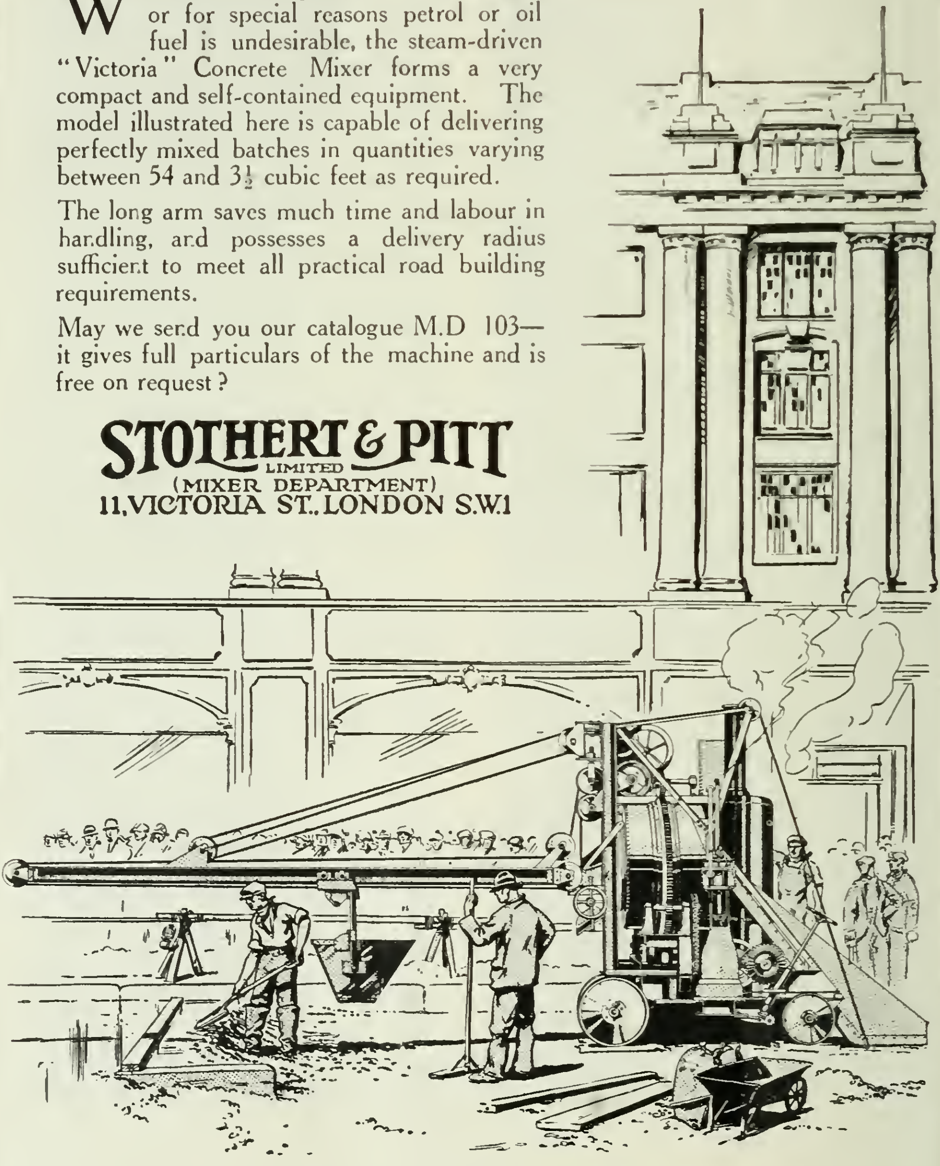


MEMORANDA.

Memoranda and News Items are presented under this heading with occasional editorial comment. Authentic news will be welcome.—Ed.

The New Secretary of the Concrete Institute.—Mr. P. L. Marks having resigned his position as Secretary of the Concrete Institute, the Council in August last appointed in his place Captain Maurice G. Kiddy, the present Assistant Secretary of the Society of Architects.

Captain Kiddy was educated at Highgate School. He matriculated at London University, and has gained prizes in English Language and Literature, French Language and Literature, and in Economics.

During the War Captain Kiddy spent most of his service with the Royal Flying Corps and Royal Air Force, and claims to have been in the air in Aeroplanes, Airships, Balloons, Seaplanes, Flying Boats,—and a parachute ! He saw service in France, Gallipoli, Egypt, and in anti-submarine work, and was wounded in France in November, 1914.

Before proceeding to the Society of Architects he was for a short time on the Editorial Staff of the London *Daily News*, and has written many short stories which have appeared from time to time in the *Royal* and other magazines.

It is expected that he will take up his duties with the Institute early this month.

New Bridge over the Muko River.—A reinforced concrete bridge, 630 ft. long and 16 ft. wide, is to be constructed over the Muko River between Mishinomiya and Osaka.

Our Roadways.—A proposal is under consideration, we learn, by the Northumberland County Council to reconstruct the trunk roads of that county in reinforced concrete. These roads suffered heavily from the war time traffic and will practically have to be re-made.

Exhibition Award.—Our Belgian contemporary *La Revue du Béton Armé*, was awarded the *Diplôme d'Honneur*, at the recent International Exhibition for Architecture and Building at Ghent.

Concrete Houses for Stirlingshire.—The Scottish Board of Health has approved a scheme of the Central District Committee of the Stirlingshire County Council for the erection of houses built of concrete blocks at Bannockburn.

Concrete Houses at Poole.—The Poole Town Council has decided to erect thirty-six houses on the Fernside estate by direct labour, and the Borough Surveyor's estimate of £611 10*s*. per house has been accepted. The houses are to be constructed of concrete blocks.

Keeping Concrete Chutes Clear.—Mr. George Goodwin in *Engineering News-Record* makes the following suggestions under this heading :—

" A simple yet effective method of keeping concrete chutes from jamming is found in the use of an ordinary chain, which is stretched throughout the length of chute. When a jam in the chute threatens, all that is necessary is to pull the chain slightly from the upper end, putting the concrete again in motion. The flow of the concrete will then pull the chain back to its normal position.

PROSPECTIVE NEW CONCRETE WORK.

Bolton.—*Sewage Works.*—The Bolton Corporation is considering the question of applying to the Ministry of Health for sanction to borrow £200,000 for extensions at the Hacken sewage works.

Bromborough.—*Sewage Works.*—The Ministry of Health has held an inquiry into an application of the Bromborough Urban District Council for sanction to a loan of £103,500 for sewage works.

Buckie.—*Waterworks.*—The Buckie Town Council is considering the question of obtaining a supply of water from new sources, and Messrs. Crouch & Hogg, consulting engineers, of Glasgow, have been appointed to prepare a scheme.

Cheadle.—*Sewage Works.*—The Cheadle Rural District Council proposes to prepare plans for a new sewage disposal scheme for the area.

Glasgow.—*Road.*—The Ministry of Transport has made a grant of £39,027 to the Glasgow Corporation towards the construction of a new road from Moss Road to Crayton Road, Govan.

Guisborough.—*Reservoir.*—Thê Guisborough Water Supply Company is considering the question of the extension of its reservoir.

Hucknall.—*Reservoir.*—The Ministry of Health has held an inquiry into the application of the Hucknall Urban District Council for sanction to borrow £30,000 for the construction of a reservoir. Messrs. W. H. Radford & Son, of Nottingham, are the engineers for the scheme.

Ludlow.—*Bridge.*—The Ludlow Urban District Council has decided to proceed with the erection ot a new bridge at Newington.

Pontefract.—*Reservoir.*—The Pontefract Corporation has approved the extension of the water supply to several new districts in its area. The scheme includes the construction of a new concrete reservoir at Red Hill. Messrs. D. Balfour & Son, of London, are the engineers for the work.

Sedgley.—*Sewage Works.*—An application of the Sedgley Urban District Council for permission to raise a loan of £22,695 for sewage works has been the subject of an inquiry by an inspector of the Ministry of Health.

TENDERS ACCEPTED.

Ashton-under-Lyne.—The Housing Committee of the Ashton-under-Lyne Town Council has, subject to the approval of the Minister of Health, accepted the tender of James Ridyard & Sons (Ashton-under-Lyne), at £1,250 per pair, for the erection of 12 " A " type houses, drainage, fencing, footpaths, etc., on the Heys Estate. Other tenders submitted were: T. Dean & Co., Ltd. (Ashton-under-Lyne), £1,280 per pair; James Green (Ashton-under-Lyne), £1,281; J. H. S. Randall, Ltd. (Sheffield), £1,286 11*s.* 1*d.*; Swallow & Taylor (Ashton-under-Lyne), £1,290; Building Guild, Ltd. (Manchester), £1,297; Marshall & Sons (Ashton-under-Lyne), £1,338; Gerrard (1920), Ltd (Manchester), £1,340; Sharples & Atherton (concrete construction), £1,355; Executors ot E. B. Charnley (Hyde), £1,358; Burgess & Galt (Manchester), £1,372 10*s.*; James Taylor (Ashton-under-Lyne), £1,377; Briggs, Sons & Renshaw (Dukinfield), £1,380; J. H. Bardsley (Manchester), £1,385; J. H. Bardsley (concrete block construction), £1,330; R. Lehane & Co., Ltd. (Darley Dale), £1,400; L. Fletcher (Castleton), £1,420; W. F. Drew, Ltd. (Stroud), £1,461; Mark Warrington, Ltd. (Hyde), £1,500; Hamiltons, Ltd. (Blackpool), £1,535.

Bromley (Kent).—Subject to modification, the West Kent Main Sewerage Board has accepted the tender of W. F. Blay, Ltd., for extensions (Contract No. 3), in connection with the sewage works. Other tenders were received from P. & W. Anderson, Ltd., £52,545; Balfour, Beatty & Co., Ltd., £66,793 4*s.* 11*d.*; F. Bevis, Ltd., £76,500; British Construction Co., £46,822; J. Byrom, Ltd., £66,997 7*s.* 8*d.*; Christiani & Neilson, £98,193 4*s.* 5*d.*; Concrete Piling Co., Ltd., £56,929 10*s.* 1*d.*; Davidson & Sykes, Ltd., £66,565 11*s.* 9*d.*; Edwards Construction Co., £48,972; Gill (Contractors), Ltd., £116,258 5*s.* 2*d.*; A. Jackman & Son, Ltd., £75,626; Walter Jones & Sons, £55,015 13*s.* 10*d.*; Kinnear, Moodie & Co., £76,643 14*s.* 3*d.*; F. Mitchell & Son, Ltd., £53,267 17*s.* 9*d.*; J. Mowlem & Co., Ltd., £62,452 15*s.* 11*d.*; S. Pearson & Son, Ltd., £78,942 3*s.* 5*d.*; Playfair & Toole, £73,384 17*s.* 5*d.*; A. Roberts & Co., Ltd., £71,200; J. Shellbourne & Co., £53,920 19*s.* 6*d.*; T. Shillitoe, £69,650; Sillwood Construction Co., £75,582 10*s.* 3*d.*; J. & W. Stewart, £69,020 12*s.* 1*d.*; Thorby & Matthews, £60,155 7*s.* 5*d.*; Unit Construction Co., £79,684 3*s.* 6*d.*; Watkins, Williams & Sons, £101,083.

Brixham.—The Brixham Urban District Council has accepted the tender of Messrs. J. & P. Dale, of Leicester, at £1,957 4*s.* 9*d.*, for the construction of a reinforced concrete reservoir and steel water main.

Chiswick.—The Chiswick Urban District Council has received the following tenders for the construction of a bridge at Wellesley Road:—Graham, Denny & Co. (London), £7,380 18*s.*; Davidson, Sykes, Ltd. (Westminster), £10,041 19*s.*; Unit Construction Co. (London), £11,137; A. E. Farr (London), £11,297; W. & C. French (Buckhurst Hill), £11,750; J. & W. Stewart (London), £11,898; J. Garlick (1910), Ltd. (London), £11,980; Yorkshire Hennebique Contracting Co. (Leeds), £13,400; Holloway Bros., Ltd. (London), £13,600; Brims & Co. (Newcastle-on-Tyne), £14,500; G. E. Wallis & Sons (Maidstone), £14,870; J. Garrett & Son (Balham), £15,426; Baldry, Yerburgh & Hutchinson, Ltd. (London), £15,408; Wilson, Lovatt & Sons (Wolverhampton), £15,729; Wimpey & Co. (Hammersmith), £17,800.

Glasgow.—The Glasgow Corporation has recommended that the tender of Messrs. Elphinstone Forrest be accepted for the concrete work in connection with the erection of 416 houses at Sandyhills, Shettleston, for the sum of £103,829 10*s.* 4*d.*

Newport (Mon.).—The Newport (Mon.) Town Council has accepted the tender of the Unit Construction Co., Ltd., of Birmingham, for the erection of 250 houses on the Somerton Estate. So far, however, the Ministry of Health has sanctioned the erection of only 110 of these houses.

Queenborough.—The Queenborough Town Council has accepted the tender of the Yorkshire Hennebique Construction Co., at £1,897, for the construction of a reinforced concrete reservoir of 175,000 gallons capacity, with ventilator covers, manholes, etc. Other tenders received were: London Structural Co., £3,475; F. Moehl & Co., £1,875; Brown & Tawse, £3,406 15*s.* 4*d.*; Queenborough Construction Co., £3,404 11*s.*; G. Munday & Sons, £2,581; T. Bugbird & Son, £3,333 18*s.*; Holloway Bros., £2,462 9*s.*; R. M. Hughes, £2,721; A. E. Farr, £2,909 19*s.*; G. Stow & Co., £4,497 8*s.*; Kirk & Randall, Ltd., £3,583; J. Gill (Contractors), Ltd., £3,894; K. Holst & Co., £2,392; L. J. Speight, £1,793.

Rugby.—The Rugby Urban District Council has accepted the tender of The Unit Construction Co., Ltd., of Birmingham, for the erection of 36 houses on the Park Estate, at £651 each for the non-parlour type, and £730 for the parlour type houses.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 11. LONDON, NOVEMBER, 1921

EDITORIAL NOTES.

EXPERIMENTAL ROADS IN SOMERSET.

DURING the autumn, winter and spring of 1920–1921 the Somerset County Council laid eight experimental sections of roadway near Bridgwater, each having a length of 220 yards and a width of seven yards. The sections comprised.

1. Monolastic paving.
2. Granite macadam grouted and sealed with asphaltmac.
3. Limestone macadam grouted and sealed with asphaltmac.
4. Tarred limestone sealed with asphaltmac.
5. Tarred limestone.
6. Granite macadam with "Vianex" binder.
7. Granite macadam with "Rocmac" binder.
8. Reinforced concrete in two sub-sections, each with a different type of reinforcement.

Sections 1 and 8 were laid by contractors, the other sections being laid by direct labour.

The report on these sections, of Mr. E. Stead, the County Surveyor, has now been issued, and provides interesting reading.

It is, of course, early to estimate the life of these various lengths, but in studying Mr. Stead's review of the whole, up to date, it would appear that in sections 1 to 7 many difficulties were experienced in laying, and the results varied considerably. In one case the surface was found treacherous owing to slipperiness ; in another, the hot weather during the recent summer brought the tar to the surface, with the result that the face remained soft, and corrugated under the heavy fast motor traffic ; in another, the surface was very brittle and during the hot weather a great deal of dust was formed by the attrition of the traffic, and a marked tendency to pot-holing was apparent ; another was described as little better than water-bound macadam. In four cases laying was dependent on fine weather. Thus it would seem that as far as these sections are concerned the experiment cannot be pronounced an unqualified success.

Now to come to the reinforced concrete. As there were no means of diverting the incessant traffic the concrete sections had to be constructed in half widths, and this not only hindered the rate of progress but, to quote the report, "also seriously prejudiced the success of the work." The latter statement is perhaps explained by what follows. "The first section opened was badly rutted through having to take the traffic in one track while the second half of the road was being reconstructed." The reason for this rutting we are unable to understand since it is stated elsewhere in the report that "each length was allowed to mature for one month before traffic was permitted to pass over it," and this period should have proved sufficient; what makes the rutting of this particular section more remarkable is that, with the exception of a certain centre joint "practically no sign of wear has become apparent since the full area of the section was opened to traffic." The explanation may possibly be found in the weather conditions. The work was commenced in September 1920, and the road, which is described as "non-slippery," was completely opened to traffic on March 24, 1921, a period which included the whole winter season, which, unless special precautions are taken, is acknowledged to be the worst possible time of year for laying concrete roads. The other explanation is that it may have been due to bad workmanship.

With regard to cost. One of the sub-sections cost 29*s.* 6*d.* per square yard and the other 24*s.* 3*d.* As we have not been supplied with a detailed statement of cost we quite fail to see how the 29*s.* 6*d.* is made up. The report tells us that the reinforcement of this particular section cost, including royalty, 5*s.* per super yard, whereas that of the other sub-section cost 3*s.* 9½*d.* In the absence of further figures we are unable to comment upon the cost, but it certainly appears to us excessive. It may, of course, be due partly to the experimental nature of the road, but in any case, in the light of what has been stated above it is easy to understand Mr. Stead's summary that as far as his experience has gone reinforced concrete is "difficult and costly to lay on main roads unless traffic can be diverted."

The difficulty, we take it, is in having to construct the road in half-widths. But this is hardly so much a difficulty as an inconvenience; but even if it be regarded as a difficulty, it is a difficulty which many road engineers have met and overcome successfully. That the difficulty of laying concrete roads is not insuperable, and the cost not excessive, is shown by the fact that the Borough Council of Southwark has, during the last two or three years, laid something like forty concrete roads, and has already embarked on a programme of many more, some of which will take the place of granite setts and others of wood blocks. Here the cost is kept down by the adoption of a practice which might well be followed by other engineers, namely that of using the material of the old road as aggregate for the new. It is, perhaps, not sufficiently realised that macadam or old concrete foundations form an ideal aggregate for a concrete road. In most of the reconstructed roads in Southwark, concrete has taken the place of macadam. In these cases, each street has provided its own aggregate. The old material, for which a few years ago the Council would have had to pay to be carted to the dump, is now crushed, washed and graded, and is used again to make the concrete, the finer stuff being used in place of sand. When it is remembered that the aggregate constitutes by far the greater proportion of the concrete the economy effected by this method will be readily appreciated.

A VISION OF THE FUTURE.

It does not require a man of very long vision, after a visit to the Commercial Motor Show recently held at Olympia, to appreciate the wonderful development of the motor vehicle, and to visualise the road transport of the immediate future.

Apart from the general interest of the whole show, there were, to our mind, three outstanding features, viz. the great increase in the size, weight and load-carrying capacity of the vehicles, the substitution of rubber for steel tyres, and the provision for winter travel by means of well-equipped and comfortable motor saloon buses.

Now let us consider what this means. Firstly, there can be no question that, in view of the state of many—perhaps we may say the majority—of our highways to-day, the existing type of road is totally inadequate to sustain the stress of modern traffic conditions, but, judging from what we have seen at Olympia, the road of the future will have to be infinitely stronger to stand up against the weight of traffic it will have to bear than any road constructed on ordinary methods. This is apparent when we find that vehicles are now constructed to carry any load up to 50 tons.

Secondly, up to the present the motor char-à-banc traffic has been mostly confined to the summer months, but now it is highly probable that with the advent of the saloon type of car there will be a considerable access of winter travelling which will contribute something further to the stress on the roads.

Finally, the methods we have adopted up to now in the construction of our roads have not kept pace with the demands made upon them ; and having regard to the enormous development of road traffic and the great increase in its weight, speed and frequency, we can only arrive at the inevitable conclusion that a new type of road is an imperative need—a type that in all respects will satisfy the new conditions and meet the new demands. We have no hesitation in saying that this type has already been found ; it is the Concrete Road, and it is surprising that with our knowledge of the success of these roads on a large scale in the United States and Canada and to a less extent on this side of the Atlantic, they have not received greater consideration and been given more frequent trials in this country.

It was gratifying to note, on inspection of the exhibits at Olympia, that the steel tyre is rapidly being replaced by rubber. This is all to the good since the former are ruinous to any road surface in time—very soon, indeed, to the older type of road—and it is not fair either to the taxpayer who has to foot the bill nor to the engineer who has to carry out the work, that the life of the road should be shortened and its efficiency impaired by the use of tyres which are now obsolete.

We have entered upon a period of remarkable development in motor transport which affects every individual in the community, and we look forward to the time when our reconstructed roads will be wider and stronger and will present a surface which approaches more nearly to the ideal, when both roads and vehicles will benefit by the abolition of steel tyres, and when, a much greater proportion of the necessaries of life being carried by road, the problem of economic distribution will be solved.

TWO RECENT FAILURES OF CONCRETE WORK IN AMERICA.

A Roof Failure.—*Engineering News Record* (August 18, 1921) gives an interesting account of a failure of a roof slab after fifteen years of service, and draws attention to this as being one of the few failures of reinforced concrete which did not occur during construction or first loading, and as raising anew the question of corrosion.

The failure was of a concrete slab 8 in. thick on a 15-ft. span forming the roof of the kitchens to the Marlborough Blenheim Hotel, Atlantic City, N.Y., and Mr. Lewis R. Ferguson made an examination which showed that the concrete was cinder concrete and the reinforcement galvanised wires ·105 in. diameter and 4 in. apart.

This failure seems to throw little light on reinforced concrete as we know it, for the following reasons :—

(1) The steel is so grossly over-stressed.

(2) Cinder concrete is recognised as being very dangerous, because, owing to its porosity, it fails to protect the steel from corrosion, and is likely to contain sulphur compounds which may even greatly accelerate it.

In regard to the first, it is perhaps sufficient to say that the dead load alone would produce a stress of about 100,000 lb./in.^{2} (about four times that allowed for high tensile wire by the least conservative of modern designers).

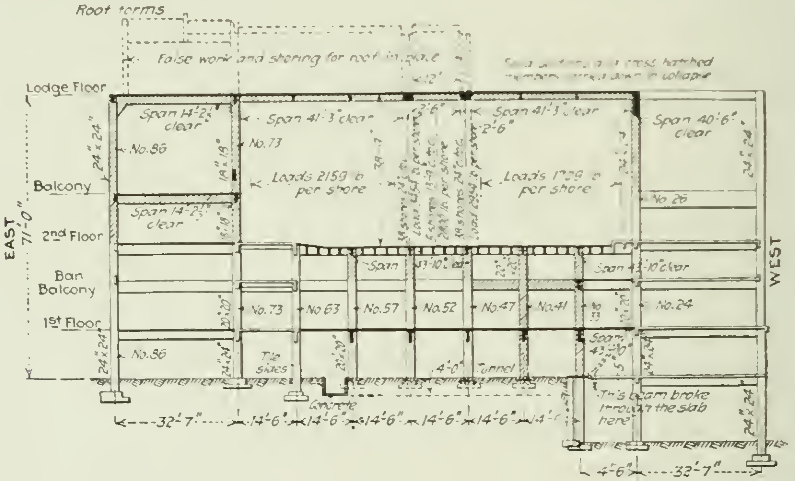
There is clear evidence that corrosion took place, and clearly the steel stress could not be raised without failure.

The failure teaches again the folly of overstressing the steel and of using cinder concrete in reinforced work, but in our view does not in the slightest degree indicate that reinforced concrete as we know it to-day has anything to fear from corrosion or age under ordinary conditions.

Collapse of a Masonic Hall.—In this instance we reproduce two sections also taken from *Engineering News Record* by the courtesy of the Editor.

It will be seen that the floor over the hall consisted of concrete beams 41 ft. span, one end of which rested on the lower member of large concrete lattice girders.

Only the bottom member had been concreted, so that the whole weight was carried on the falsework and transmitted on to the lower floors.



Longitudinal Section, Looking South.

An analysis of the structure by the engineers appears to show that failure was due to a combination of the following causes:—

(1) The falsework was totally inadequate and had already shown signs of buckling.

(2) The lower floors were quite inadequate in design, the shear stresses amounting in some cases to 420 lb. per square inch, and the tensile stresses in the steel in some cases to 36,000 lb./in.^{2}

(3) The concrete was very weak, tested specimens showing only 921 lb. per square inch [at least forty days old], and the stone appeared to be soft.

(4) There is evidence also that the lower shores rested on soft clay, and

(*Continued at foot of page* 709.)

CONCRETE CONSTRUCTION ON THE LONDON AND NORTH-WESTERN ELECTRIC RAILWAY.

An instance of the many uses to which concrete can be put in connection with railway work is to be found in the interesting description we publish below of work on the London & North-Western Electric Railway.—ED.

THE work on the L. & N.W. Railway new electric line, which was suspended by the war, was resumed in August, 1919. The portion remaining to be completed extended from Queen's Park, where the junction with the London Electric Railway is situated, to Chalk Farm, where the electric lines join the existing steam lines, and extend to Euston and Broad Street on the surface.

The iron lined tunnels had already been driven below Primrose Hill, and to complete the original design it was necessary to continue them towards Euston in brick tunnels, built on the cut and cover system, effecting the junctions of the Euston and Broad Street lines below ground in specially built junction chambers, and carrying all four lines in tunnel upwards on a gradient until they could be brought to the surface in the open between retaining walls. Part of this cut and cover work had already been finished in brickwork, but there remained to be completed the down lines junction chamber, and the whole length of the tunnel for the down electric line from Euston.

At the time when the work was recommenced, all brickwork was rendered extremely difficult and costly by the scarcity of materials and labour, and the great uncertainty in the delivery of such materials as were available. Following usual L. & N.W. Railway practice, all brickwork had originally been specified as faced with blue Staffordshire bricks, and these proved, at the time, almost impossible to obtain in any quantity.

After very careful consideration, therefore, it was decided by the Chief Engineer of the L. & N.W. Railway to complete this portion of the work in concrete, as it appeared certain that both a reduction in cost and an increase in speed of execution would be obtained by this method. The work was accordingly put in hand, and the down lines junction chamber, and the down electric tunnel, referred to above, have now been completed in concrete.

The cement used throughout the work was to the British Standard Specification for slow-setting Portland cement. All cement as received, in consignments of about ninety tons, was conveyed to the contractors' yard at Stonebridge Park, where it was stored in specially constructed cement sheds. Samples were taken from each consignment, and no cement was used from such consignment until the completion of a full twenty-eight days' test of the samples taken.

The aggregate used throughout the work, with the exception of the waterproofing courses above the arches, was clean Thames ballast. This was found satisfactory in composition, without the admixture of sand. For the fine concrete in waterproofing courses, and for certain special purposes to be referred to later, the aggregate used was clean granite chippings, broken to pass a half-inch ring, with a suitable admixture of Leighton Buzzard sand.

The proportions used for the different parts of the work were as follows :—

(1) For the foundations throughout.	8 to 1 ballast concrete.
(2) For the inverts, walls, and arches of the tunnels.	6 to 1 ballast concrete.
(3) For the fine concrete in waterproofing courses, etc.	1 of cement to 4 of aggregate, such aggregate consisting of granite chippings and sand in the proportion of 4 to 2.

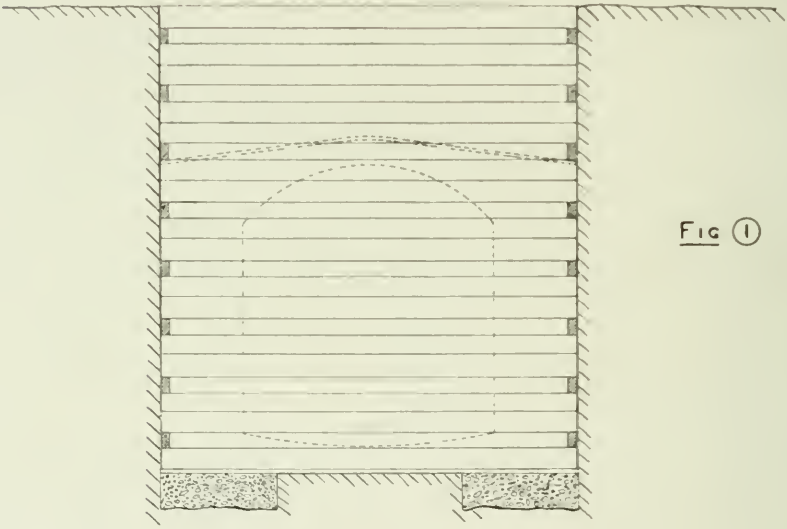


FIG ①

Owing to the fact that the work had to be executed in the midst of the existing running lines of the Company, and extremely near to some of them, it was necessary to complete the tunnels in short lengths of about 27 ft., in order that no risk should be taken of causing a subsidence of the permanent way. The method adopted generally was to take out alternate short lengths, and build them complete with the permanent structure before disturbing the ground in the intermediate length. This procedure naturally involved very careful scheming for crane and filling roads, etc.

The method employed in a typical length was as follows :—

A hole was set out and sunk, for the full width of the finished tunnel, including the thickness of the walls. The excavation was all in London clay, and very careful close timbering was adopted throughout. On reaching the level of the bottom of the invert of the finished tunnel, the excavation for the foundations of the side walls was carried down to the necessary depth, and the foundations poured at once in 8 to 1 concrete (*Fig.* 1).

Moulds were then set in the bottom of the hole, three of these being used in the case of a 27-foot length. The tops of these moulds were carefully adjusted to represent the top of the finished invert. The invert was then poured in 6 to 1 concrete, the top being screeded off between the moulds with long straight edges (*Fig.* 2).

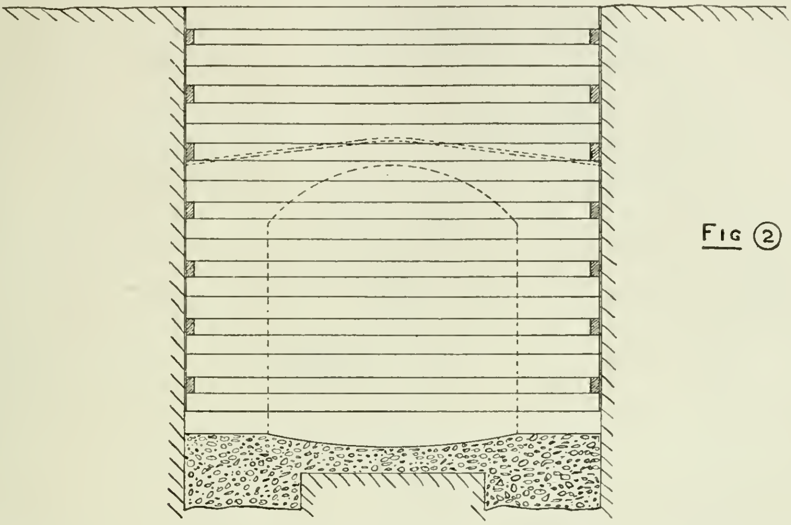


FIG ②

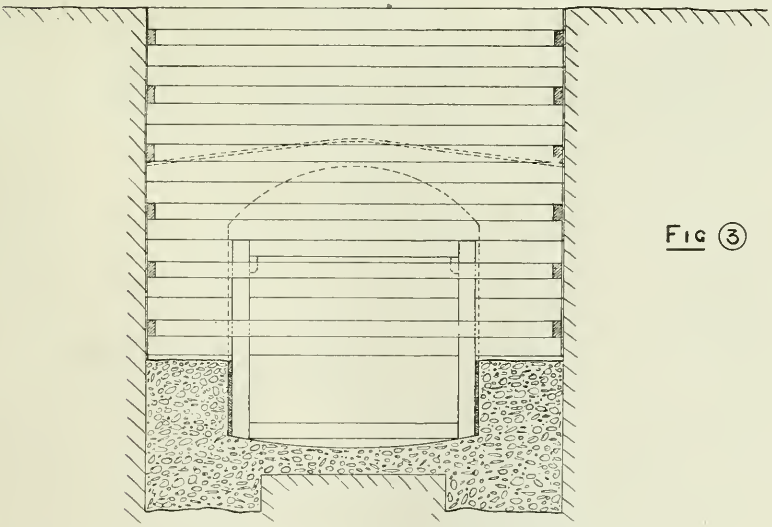
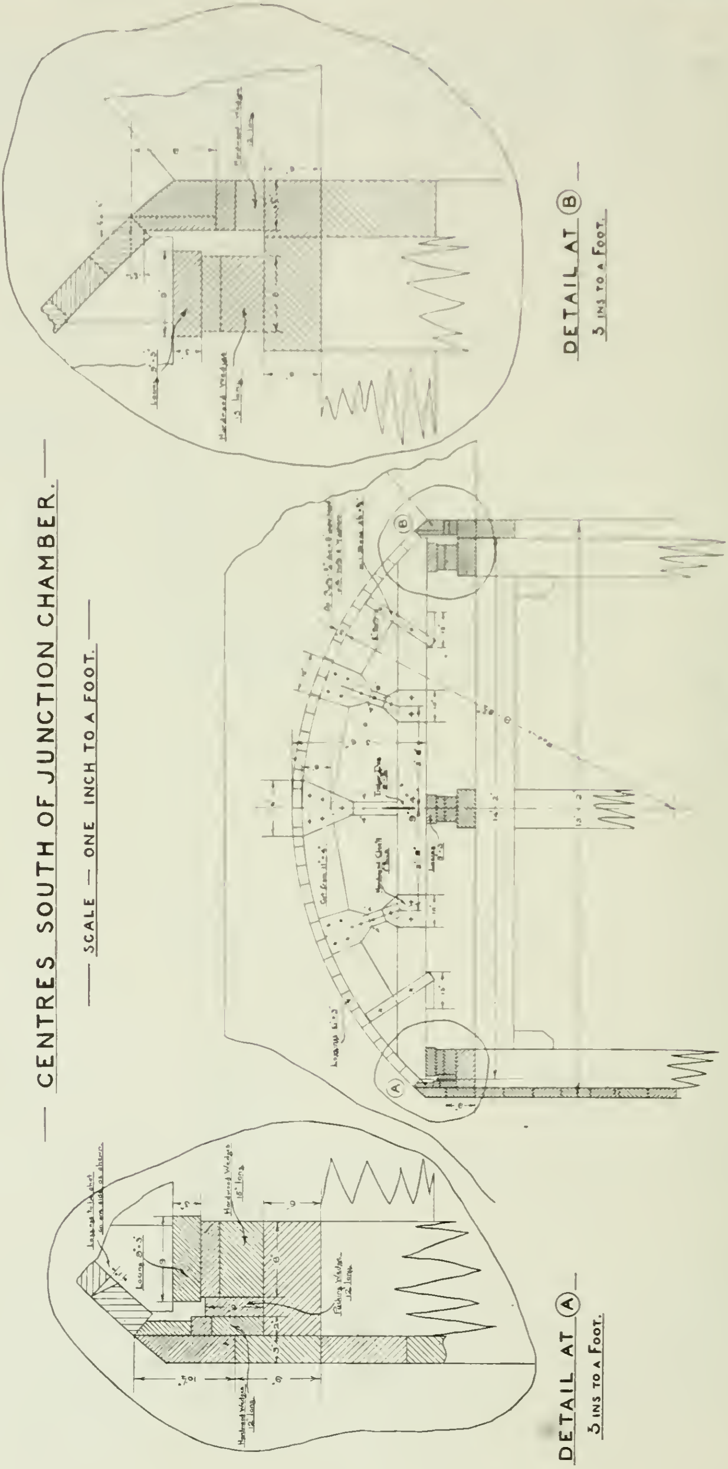


FIG ③

As soon as the invert had set sufficiently, the shuttering for the side walls was erected. This was of timber, consisting of 9 in. × 3 in. planks, planed on one face and shot on the edges, and supported by heavy vertical timbers, or "soldiers," extending for the full height of the walls, and stretched at top and bottom by similar timbers. The concrete walls were then poured in "lifts" of about 3 ft. 6 in., one frame of the ordinary timbering of the hole being struck,



CENTRES SOUTH OF JUNCTION CHAMBER.

SCALE — ONE INCH TO A FOOT.

DETAIL AT (A)

3 INS TO A FOOT.

DETAIL AT (B)

3 INS TO A FOOT.

FIG. 4.

and the concrete wall brought up at once, so that the clay side of the excavation was never exposed for a height exceeding the length of one poling board, and then only for a very short period (*Fig.* 3).

On arrival at the springing level of the arch, the centreing was set, being

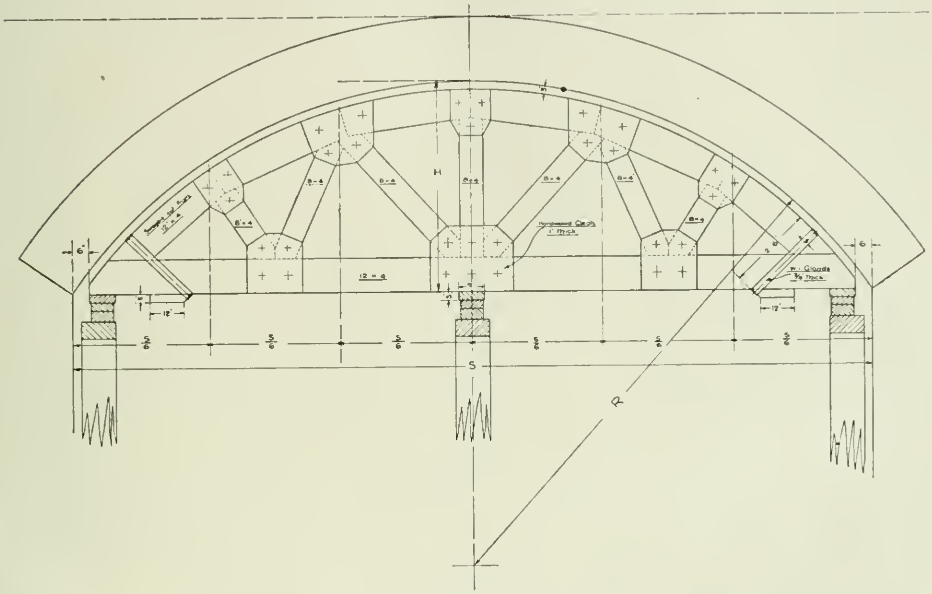
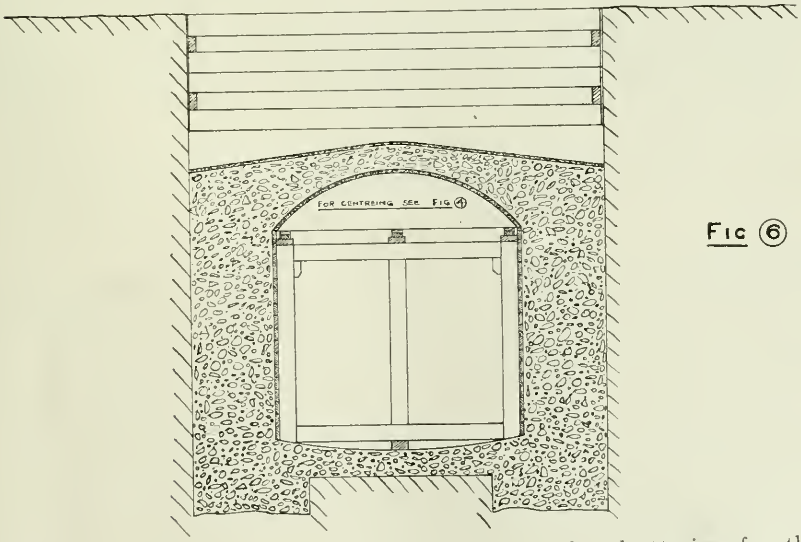


Fig. 5. Type of Rib for Part of Junction Chamber.



Fic ⑥

supported on the tops of the "soldiers" carrying the shuttering for the side walls. The centreing was specially designed for this work, and was of a much stronger nature than would have been employed for a corresponding brick arch (*Figs.* 4 and 5).

It should here be remarked that, to avoid difficulties in the general lay-out of the scheme, the brick dimensions as originally designed were maintained throughout.

The arch and backing, of 6 to 1 concrete, was then poured over the centreing, and screeded off on the top between moulds to give the required camber for drainage, and a layer of fine cement concrete 2 in. thick was placed all over the backing, to form the waterproofing course. The remainder of the hole was then filled in (*Fig.* 6).

The concrete was mixed on the surface throughout, two ¾-yard mechanical batch mixers being employed. The mixers discharged into ¾-yard bale skips which were lowered by cranes through the open panels of the timbering, and emptied where required. In some cases, where the skips could not be lowered direct, timber chutes were employed.

Apart from the cut and cover construction referred to above, concrete has been used for many purposes during the completion of this railway. In the parts of the tunnel which were completed in brickwork, cement concrete skew-backs were used instead of stone. All flags used for covering manholes, etc., have been made of concrete, granite chippings being used as the aggregate. Blocks set in the copings of the brick walls to carry the hand rail standards have also been made of this material.

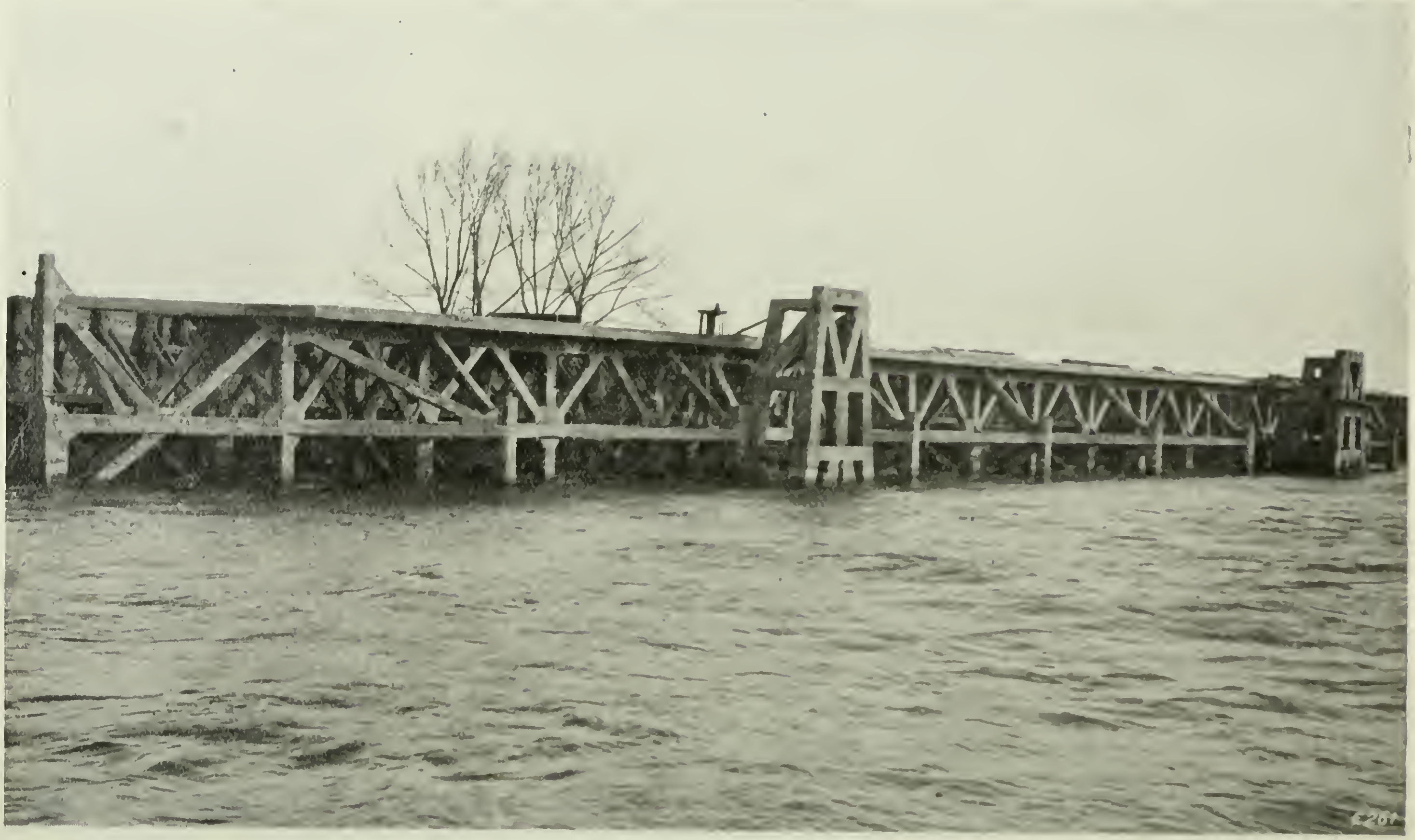
The footways through the iron-lined tunnels are being constructed of concrete blocks, made on a Winget machine, so formed as to provide cable ducts in the face of the wall. A retaining wall at Kilburn some 400 ft. long has been constructed entirely of concrete.

The portion of the tunnel constructed in concrete has proved perfectly satisfactory, being very free from damp, in spite of the fact that it was, of necessity, constructed in such short lengths.

The work has been carried out under the direction of the Chief Engineer of the London and North-Western Railway, Messrs. John Cochrane & Sons, Ltd., of 39 Victoria Street, S.W., being the contractors, to whom we are indebted for our particulars.

MEMORANDUM.

Coke Breeze.—A store-house has been built at East Ashland, Kentucky, of coke breeze concrete blocks. The breeze was obtained from a neighbouring coke oven plant, operated by the Kentucky Solvay Coke Company, and had passed a ¾ in. screen. The blocks were made by mixing coke breeze and cement in proportions of two ordinary wheelbarrows of breeze to one sack of cement. The breeze contains just about the proper mixture of large and small particles to take the place of any first-class fine gravel. The floor of the building referred to was also made from a mixture of breeze and cement, using two wheelbarrows of breeze to one and a-half sacks of cement. The building blocks are exceedingly hard, and are expected to withstand weathering considerably better than the usual cement blocks. The floor also turned out very well, and, it is thought, should outwear an ordinary cement floor. The brief experience gained in the erection of this building has indicated no difficulties whatsoever; and it is felt that, in connection with those plants where, due to local conditions and lack of proper equipment for the consumption of breeze, its disposal is a matter of difficulty, this method may open up a new market, particularly if the local price of gravel is high.—*Gas Journal.*



Brulée Quay: Extensions to the Port of Nantes and the Loire.
(*See page* 705)

General View of Donges Quay.

EXTENSIONS TO THE PORTS OF NANTES AND THE LOIRE.

It may surprise most of our readers to learn that in consequence of the declaration of war in 1914, the port of Nantes has been completely transformed. At that time vessels of 20-ft. draught could be accommodated, but it was necessary to provide for those of 25 ft., and special facilities had to be secured for the rapid loading and unloading of a very large number of vessels of all sizes. Extensive alterations had been carried out in 1912, and were incomplete on the outbreak of war, but they had increased the capacity of the port by 30 per cent. over its figure for 1910; this and the following figures show what was accomplished:—

Year	Tons of goods into and out of the Port	Year	Tons of goods into and out of the Port
1910	1,533,660	1916	2,891,778
1912	2,100,017	1917	1,849,248
1915	2,566,739	1918	2,235,458

The traffic for 1919 surpassed all previous figures, and the credit of this is chiefly due to the extensions carried out during the war.

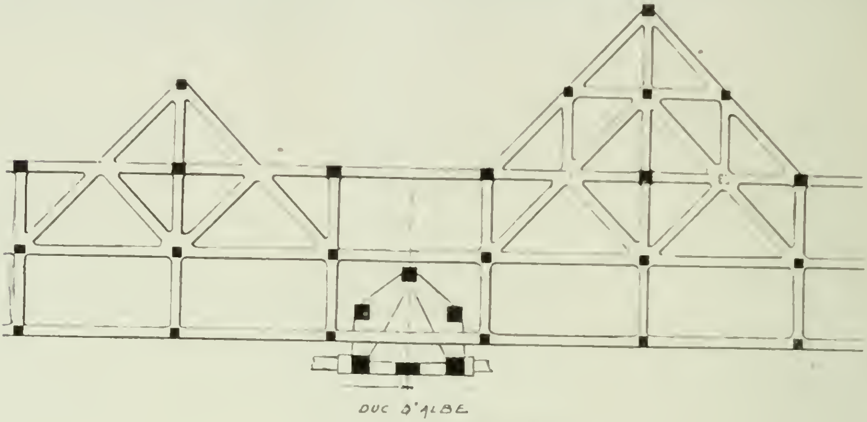
Owing to the exigencies of war it was necessary to make the extensions in the shortest possible time and in the simplest manner. Moreover, as the ordinary workmen were not available, it was necessary to employ large numbers of prisoners of war with a few skilled workers who were released specially from military duties for that purpose.

The foundations were laid on piles of reinforced concrete, and the superstructure was also of reinforced concrete, because the existence of an abundance of sand and gravel in the neighbourhood afforded special facilities in the use of this material.

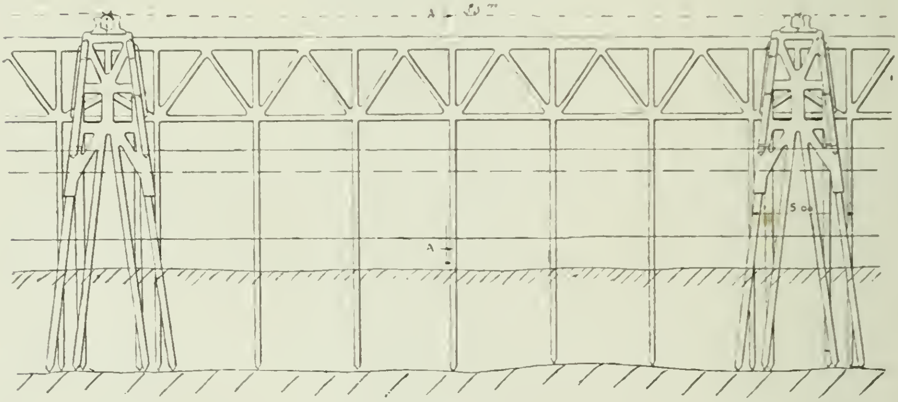
THE PAIMBOEUF QUAY.

The Paimboeuf Quay, with a length of 833 ft., was built to store sulphuric acid, melinite and other explosives, as well as large quantities of metal and other war materials unloaded along the south bank of the Loire. It is situated above Paimboeuf, 200 ft. in front of the south bank, and is joined to the latter by two parallel jetties 386 and 380 ft. in length respectively, which make an angle of 46 ft. degrees with the shore. The anchorage of vessels of 3,000–4,000 tons is ensured by means of eight mooring wharves placed 120 ft. apart, each wharf consisting of seven piles, four parallel to the quay and the remaining three behind them. These piles are 16 in. square, and are driven down through about 16 ft. of sand to the rock beneath.

The jetty carrying the travelling cranes is independent of the mooring-posts, and consequently has only to withstand the vertical pressures resulting from the loads placed upon it. This jetty extends from the embankment which forms the edge of the solid ground and is connected thereto by the railroad and by the supports of the conveyors.



PART PLAN OF PAIMBOEUF JETTY



PART ELEVATION OF PAIMBOEUF JETTY.

The foundation of the jetty for carrying the 5-ton cranes and the railway trucks is 18 ft. wide, and consists of three lines of reinforced concrete piles 10 in. square placed 8 ft. apart in one direction and 17 ft. apart in another. Each of the three rows of piles is strengthened on the land side by abutment piles, and all nine rows of piles are further strengthened by four abutment piles each 1 ft. square. The jetty proper is connected to these abutments by horizontal and inclined beams, and its superstructure is formed by the extension of the supporting piles. In a transverse row of piles the heads of the latter are connected by a beam 22 in. deep and 12 in. wide, forming the main transverse girder of the bridge.

The upright piles are also tied at the sides by a beam 12 in. square fixed 9 ft. above mean water level, and by numerous ties so arranged as to reduce the reactions transmitted to the middle row of piles. The beams supporting the crane-tracks and forming the embankment and the beams of the jetty platform are all 22 in. thick. The whole jetty is faced with rough-cast.

For a distance of 360 ft. riverwards there is a band conveyor, carried on a corbel 6 ft. wide. A connecting beam of 80-ft. span connects the conveyor with the railway. A foot-bridge 18 ft. wide on the up-river side of the jetty is built in a similar manner to the jetty, and rests on three rows of piles each 1 ft. square and placed 25 ft. apart. The bracings to resist wind pressure are restricted so as to permit the free circulation of the water under the jetty.

A further bridge carrying a transporter is similarly arranged, and is built on piles 13 in. square, placed 25 ft. apart so as to support the transporter. The floor of this bridge consists of rough-cast 4 in. thick, supported on transverse joists 2–3 ft. thick and 18 in. wide, which rest on the top of the piles. The Paimboeuf Quay was commenced late in 1915 and completed in June 1917 at a cost a thousand francs per linear foot.

Notwithstanding the difficulties of obtaining materials and labour, says A. Kauffmann (engineer-in-chief), a length of 400 ft. was added to the Permil Quay in 1916, an extension of 200 ft. on piles and 1,000 ft. on arches was completed in 1917, and at the commencement of 1919 an extension of 666 ft. of quay on piles and 730 ft. on arches had been completed, so that during the war no less than 3,000 ft. of additional wharfage, providing accommodation for eight vessels each 400 ft. long, had been added.

An important group of warehouses has been built at Paimboeuf, about 30 miles nearer the sea. Access to these is by means of a jetty 830 ft. long, built of reinforced concrete, and two transverse jetties of the same material.

On the right bank of the river at Roche Maurice are three mooring wharves for large vessels—two of these being built in 1914–16, and the third in 1919—and at all these the water is never less than 26 ft., even at the lowest tides, and behind these wharves is a jetty carrying the cranes so arranged that the vessels are discharged directly into the trucks. The arrangement is completed by extensive sidings, which facilitate rapid transport.

THE DONGES QUAY.

Another large jetty, 1,200 ft. in length, has been erected at Donges, ten miles from St. Nazaire, and opposite Paimboeuf, and at this jetty there is ample water at all times to float vessels of 23-ft. draught. This jetty is connected to the Orleans Railway. The Donges Quay is of the same type as that at Paimboeuf, and is specially designed for coaling vessels. It has a length of 1,200 ft., and consists of thirteen loading wharves similar to those on the Paimboeuf Quay, placed 66 ft. to 130 ft. apart, and designed to withstand a tension of 15 tons at their head. Each of these wharves is built of eight piles 30–70 ft. deep, which are driven right down to the solid rock. The crane-carrying jetty runs parallel to these wharves, and has a length of 1,200 ft. It is provided with two railway tracks and one crane track, each 800 ft. long, the transportation of goods on the remaining portion being effected by a conveyor. The quay is connected to the land and the main railway system by two other jetties built specially for railway traffic.

The anchorage for petroleum tankers belonging to the Compagnie Occidentale des Produits du Petrole at Donges consists of four mooring wharves, and can accommodate 8,000 tons of oil. A wooden jetty 30 ft. by 27 ft. carries the discharging plant consisting of pumps and engine which lifts the petroleum out of the vessel and transfers it to a piping system of 8–10 in. diameter, through which it is carried ashore. The four mooring wharves are 250 ft. apart; they are more robust than those previously described, and are designed to withstand a stress of 20 tons on each capstan.

Each wharf is built on fifteen piles 18 in. square and 66 ft. long driven down to the rock, 40 ft. being in the ground. The piles are surrounded by sheaths of precast reinforced concrete, and the upper part of the wharves is strengthened by cross piles and ties. In other respects these wharves are the same as the similar wharves at Paimboeuf. The petrol wharves were built in six months, during the year 1919.

Landing Stage for Petrol Vessels.

THE BRULÉE PIERS.

The Brulée piers were built in a more accessible part of the river, so that less difficulty was experienced in their construction. They are so close to the land that the railway track running along the latter can be loaded directly from the ships by cranes built on the piers.

The loading wharves and jetty are of the same type as those at Paimboeuf, but the beams and joists used in the construction of the jetty were arranged in trellis work so as to transmit the reaction of the cranes to a number of piles each of which could transmit a pressure not exceeding 4–7 tons to the foundation. This precaution was necessary because the piles were driven down to the rock, and this probably resulted in weakening them by concussion with the latter.

The supporting wall, 30 ft. from the centre of the crane-track, is built temporarily of wood.

Special attention has been paid to the use of labour-saving appliances. For example, all cereals at Port Maillard and Andre Rhuys are handled by means of eight elevators, which can deal with 1,600 tons per day. Two Poulson machines, six sack fillers and weighers, and two motor-driven sacking machines are also used. Since 1915 four sack-filling and weighing machines and nine automatic grabs have been employed by the Chamber of Commerce. The civil authorities have installed a pneumatic discharging machine with an output of a thousand tons per day.

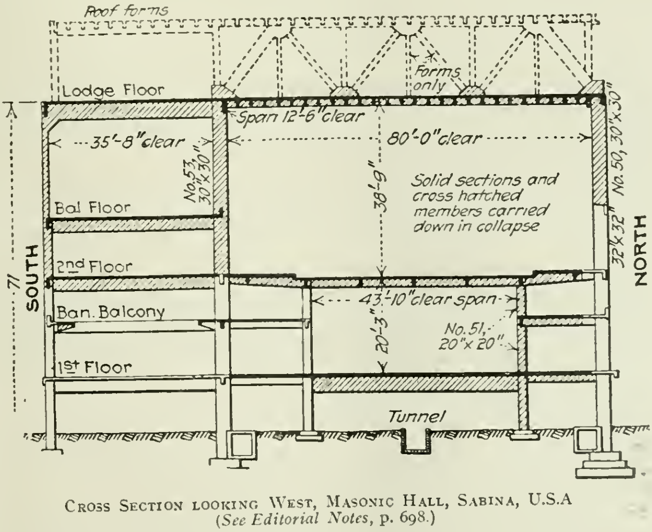
Coal is transported by three 3-ton steam cranes at the Permil Quay, and by nineteen electric winches, of which ten are at the Antilles Quay, and nine on the Roche-Maurice Quay. At the Paimboeuf Quay coal is raised by four electric 5-ton cranes, and there are in addition thirty-four other 3–7-ton cranes in different parts of the port area.

In short, during the war no less than sixteen new loading wharves were built for large seafaring vessels, and six others for internal transport. This is equivalent to an increase of 39 per cent. in the capacity of the port. More recently further extensions for vessels, 480–550 ft., have been commenced on the left bank of the river near Roche-Maurice.

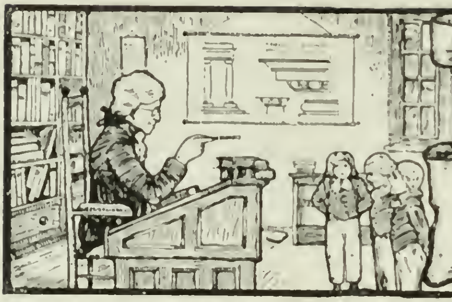
(*Continued from page* 698)

that these squeezed in and so put the weight of the floor over the hall on to the lower floors, which were hardly strong enough to carry themselves.

Under these circumstances it cannot be said that the failure in any way discredits reinforced concrete, but rather goes to show that the well-known requirements for success were ignored, and emphasises once more the importance in reinforced concrete of a competent engineer.



Cross Section looking West, Masonic Hall, Sabina, U.S.A
(*See Editorial Notes*, p. 698.)



SIMPLE EXAMPLES OF REINFORCED CONCRETE DESIGN.

By OSCAR FABER, O.B.E., D.Sc., etc.

Preface.—These examples are intended to assist a student or a beginner in reinforced concrete design to produce reasonable designs for simple structures.

They are intended to be simple practical applications of the principles enunciated in *Reinforced Concrete Simply Explained*, which first appeared in the form of articles in *Concrete and Constructional Engineering* and subsequently is being reprinted and published in book form by the Oxford Technical Publications.

They are not intended, therefore, to represent the author's views on the most finished or economical design, and it is to be clearly understood that the author would in many cases allow an experienced designer to adopt somewhat smaller sections or reinforcements. But this needs a thorough understanding of many *finesses* in design, coupled with a good judgment of whether the conditions under which the *execution* of the work will be undertaken are likely to be good or bad—the workmanship, quality of materials, weather, supervision, etc.—and the knowledge and experience of these matters cannot fairly be expected in a beginner in design.

What *is* aimed at is to present in a simple form, designs of simple structures which under average conditions of workmanship, etc., ought to give satisfactory results. Obviously a structure of any magnitude or importance ought always to be designed and constructed under the supervision of a really competent and experienced man, whose fees are saved many times over by the greater economy of his design and the certainty that the result will be a lasting success. The simplest and clearest language will be used at the risk of wearying readers with previous knowledge.

Example 1.

Circular water tank, 10 ft. diam., 10 ft. high, resting on the soil.

Design.—If a flexible cup of the same shape as our tank, namely, cylindrical top and flat bottom, is made of waterproof fabric of any kind and stood on a flat board and filled with water, it will be found that the water will exert a pressure against the sides which will cause them to take up a circular form.

Such a cup will be found to be quite a satisfactory container for water on a small scale, and obviously fulfils the functions, as regards structural resistance, which our tank has to resist.

Now it is clear that the cup of flexible fabric cannot anywhere be exposed to bending or compression stresses, because if it were, the material, being flexible, would simply bend or buckle and collapse, which we find does not occur.

It follows from this that a cylindrical tank with a flat bottom uniformly supported is not subject to anything but pure tensile stress.

This simplifies the design very much.

The same result may be obtained from many other considerations such as those of symmetry.

To calculate the amount of the tension, consider a view of the tank from above (called a *plan* view) at some particular depth where the water pressure is p pounds per square foot, and let D be the diameter of the tank, in feet.

Now as the pressure of water varies at different depths, it is best to confine our attention to a strip or section of the tank (see *Fig.* 1 *b*) of a small height for which the pressure may be considered near enough constant. It is near enough for our purpose to take it one foot high.

Our section of tank is then D feet in diameter, 1 ft. high, and is bounded by a section of tank wall also 1 ft. high, the tension in which resists the water pressure, pressing against it and tending to burst it.

To find what the actual tension in our section of wall is, let us consider the forces acting across a diameter, as shown on *Fig.* 1 *a*.

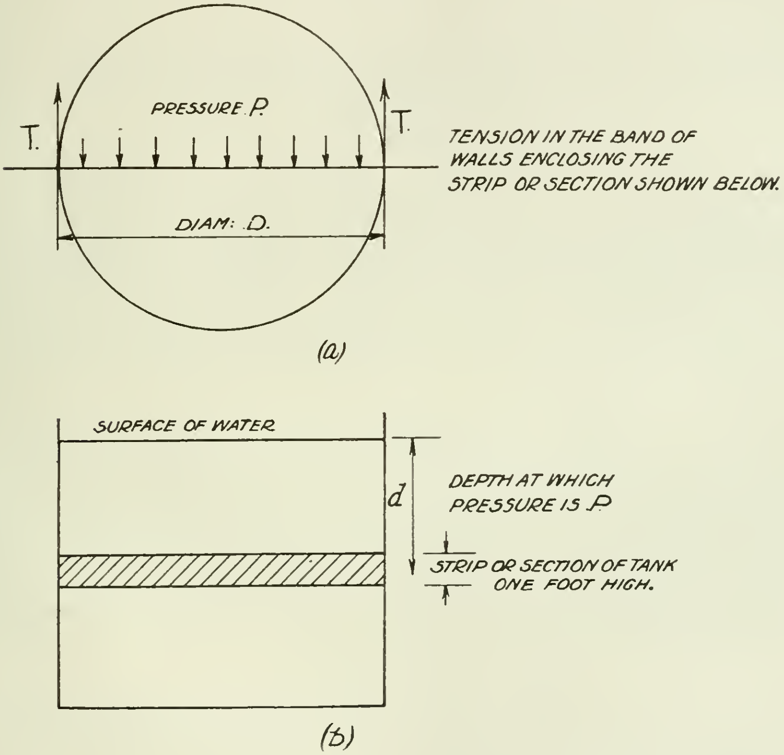

T.
PRESSURE P.
T.
TENSION IN THE BAND OF WALLS ENCLOSING THE STRIP OR SECTION SHOWN BELOW.
DIAM: D.
(a)
SURFACE OF WATER
d
DEPTH AT WHICH PRESSURE IS P
STRIP OR SECTION OF TANK ONE FOOT HIGH.
(b)

FIG. 1.

The pressure of water is p lb. per square foot and acts on an area D ft. wide and 1 ft. high, so the total pressure on the diameter of the section is :

$$P = p \times D \times 1 \text{ pounds}$$

The only forces resisting this are the tensions T in the two sides of the wall of the section. Clearly these forces $2T$ and P must be equal, since if one were the greater, it would pull the tank over, just as in a tug-of-war, if one side pulls stronger than the other movement occurs.

Hence

$$2T = P = pD$$

$$\text{or } T = \frac{pD}{2} \qquad (1)$$

This is a general equation which applies to the tension in any circular receptacle resisting internal pressure, and is used in the design of pipes, boilers, etc.

Now the pressure of liquid at any depth d is

$$p = wd$$

Where w is the weight per cu. foot
d is the depth in feet
p is the pressure per square foot.

Substituting this value for p in equation (1)

$$T = \frac{pD}{2} = \frac{wdD}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In the case of water, $w = 62\frac{1}{2}$

$$\text{so that } T = 32\tfrac{1}{4}\, dD \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2a)$$

In our tank, the maximum pressure is clearly in the lowest foot of tank, and the maximum tension in the lowest foot of wall. In this, the mean depth is $d = 9\frac{1}{2}$ ft.

Whence the tension in the lowest foot of wall is

$$\begin{aligned} T &= 32\tfrac{1}{4} \times 9\tfrac{1}{2} \text{ ft.} \times 10 \text{ ft.} \\ &= 3{,}050 \text{ lb.} \end{aligned}$$

Now in reinforced concrete design we do not rely on concrete to resist tension, and therefore we must put enough steel in this foot of wall to resist this pull of 3,050 lb.

Now we have to decide what stress we will go to in our steel reinforcement. Steel has a breaking strength of about 64,000 lb. per square inch, but at about half this (32,000 lb. per square inch) it stretches or yields. In ordinary practice, a factor of safety of 2 on the yield point is often used, giving a safe stress of 16,000 lb. per sq. in.

In the case of concrete tanks, it is hardly advisable to go even as high as this, except in special cases, because a stress of 16,000 lb. per sq. in. in the steel involves a stress of

$$\frac{16{,}000}{15} = 1{,}066 \text{ lb. per sq. in.}$$

in the concrete, which, being greater than it will resist in tension, means that it will crack.

These cracks are so small that in ordinary reinforced concrete structures they do not matter, but in structures depending on the concrete for watertightness, they are obviously undesirable.

The author recommends for small tanks a *nominal steel stress of* 8,000 *lb. per sq. in. and a percentage of steel not exceeding* 1 *per cent. of the concrete by volume.*

It is true that 8,000 in the steel corresponds to

$$\frac{8{,}000}{15} = 503{\cdot}3 \text{ lb. in.}^2$$

in the concrete, which is about twice the ultimate, but experience justifies the practice, and the explanation is the following.

Though, in accordance with good practice, the steel is designed to carry the whole tension at a safe stress, and the resistance of the concrete is neglected, yet if the percentage of steel is not too high it does not at all follow that this condition will exist, as may be shown as follows.

Consider 1 sq. in. of steel in 99 sq. in. of concrete, subjected to a pull of 8,000 lb.

Here we clearly comply with our rule, namely, 8,000 lb. per sq. in. in the steel, concrete neglected, and percentage of steel 1.

Now up to the point when the concrete cracks, the concrete and steel will act together, the steel, however, taking 15 times as much stress as the concrete owing to its higher elastic modulus and being therefore equivalent to fifteen times its area of concrete, just as was explained for Columns [see *Reinforced Concrete Simply Explained*].

The *equivalent area of concrete*, in other words, is 99 sq. in. of concrete + 15 sq. in. [equivalent of 1 sq. in of steel]

$$= 114 \text{ sq. ins.}$$

on which, clearly, the pull of 8,000 lb. exerts a stress of

$$\frac{8000}{114} = 70 \text{ lb. per sq. in.}$$

This is quite a safe stress, well below the breaking stress, and explains why the concrete can remain watertight.

Although the *nominal steel stress* neglecting the concrete was 8000 lb./in.^{2}, the *actual steel stress* will be $15 \times 70 = 1050$ lb./in.^{2}, and owing to the stress in the concrete being so low (70 lb./in.^{2}), cracking of the concrete is not likely to occur.

Let us now adapt our rule to our present example.

The bottom foot of wall has a tension

$$T = 3{,}050 \text{ lb.}$$

At a nominal stress of 8,000 lb. per sq. in., this requires an area of steel

$$A = \frac{3050}{8000} = \cdot 38 \text{ ins.}^2$$

Now $\frac{1}{2}$ in. rods have an area of ·19 ins.^{2} so that 2—$\frac{1}{2}$ in. diam. rods in the foot of wall, that is, at 6 in. centres, will do nicely.

If we make our walls 6 in. thick, the percentage of steel would be

$$\frac{\cdot 38 \times 100}{12 \times 6} = \cdot 58,$$

which, being less than the 1 per cent. maximum suggested by our rule, is satisfactory.

As regards thickness of walls, the following are recommended as minimum thicknesses —

Depth of water in feet.	Thickness in inches.
3 and under	3
6 ,, ,,	4
9 ,, ,,	5
12 ,, ,,	6
15 ,, ,,	7

and so on.

These are to be increased if our 1 per cent. rule, or other considerations give greater thicknesses and are the minimum from considerations of preventing water oozing through the wall, quite apart from cracks and stresses.

As the pressure gets proportionately less at a lesser depth from the top, the steel can be reduced, or the bars placed further apart.

Thus, a strip 1 ft. high 6 ft. down, instead of 10 ft., would need an area of

$$\cdot 38 \times \frac{6}{10} = \cdot 228$$

At this point, therefore, $\frac{3}{8}$ in. rods at 6 in. centres would do.

In the author's view, this should be considered a minimum.

Vertical rods are very desirable. These serve to connect the concrete of different layers, which may be placed on different days. They cannot be calculated, but should be about ·5 per cent. of the concrete, say $\frac{3}{8}$ in. rods at 6 in. centres.

The bottom, if uniformly supported, has no stresses, but $\frac{3}{8}$ in. rods in both directions add little to the cost and serve to resist accidental stresses.

The vertical bars should be bent into the bottom as shown so as to prevent a crack at the internal angle between the sides and bottom.

The concrete should be

$\frac{3}{4}$ in. broken stone or shingle	3 parts
clean sand	1$\frac{1}{2}$,,
Portland cement	1 ,,

The horizontal joints between successive days' concreting often show leaky places owing to the stones not bedding on to soft mortar but concrete already set.

This danger may be greatly reduced by placing half an inch of mortar, composed of two parts of sand to one of cement on the old work and following the concrete on to this at once.

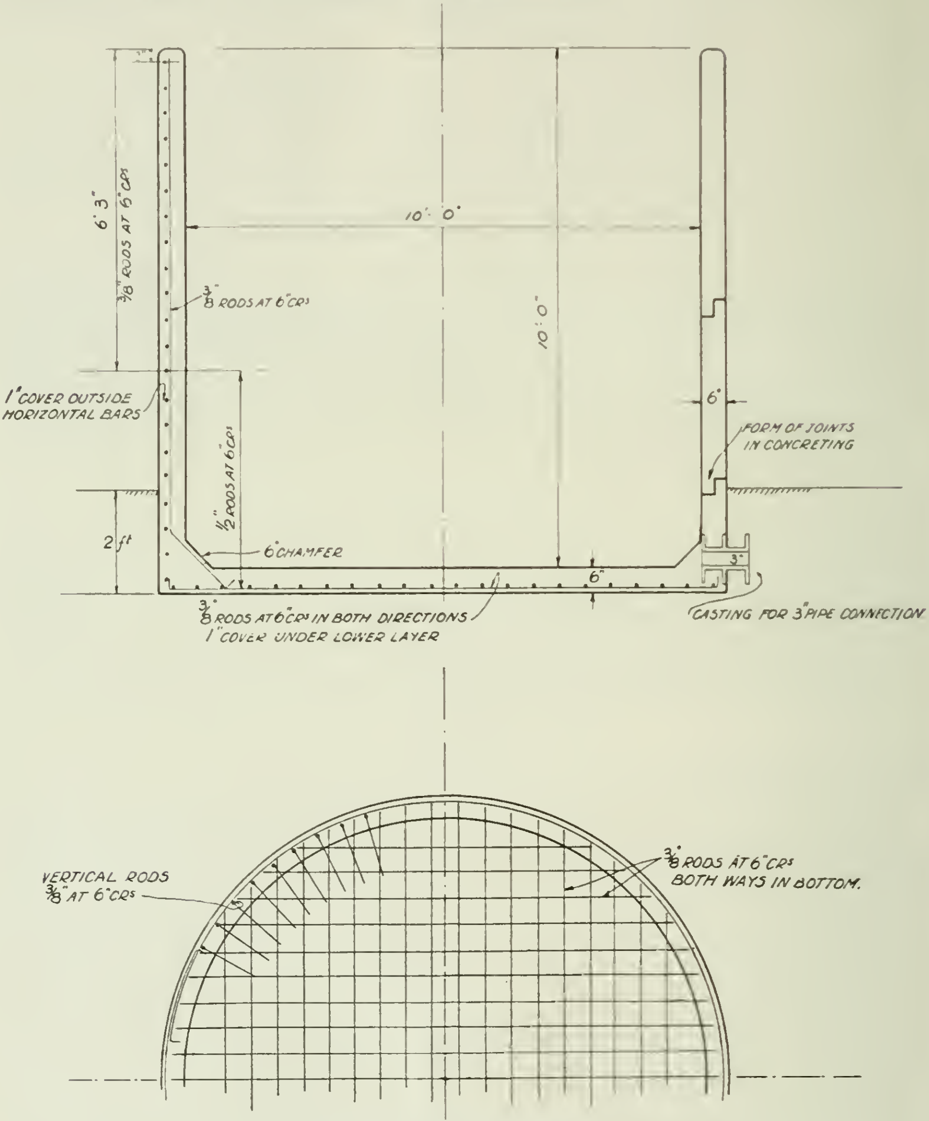
Another good precaution is to leave rebated finishes, as indicated in the drawing. *Fig.* 2 gives a complete working drawing.

The horizontal rods are conveniently made in two lengths. This should overlap at each joint by 2 ft. and have a hooked end.

The rods should have 1 in. cover of concrete for protection.

Obviously only a dense watertight stone should be used.

If any leaking should occur, an internal rendering of one part cement to 2½ parts sand will probably cure it, but should not be necessary.


6' 3"
3/8" RODS AT 6" CRs
10' 0"
10' 0"
3/8" RODS AT 6" CRs
1" COVER OUTSIDE HORIZONTAL BARS
6"
FORM OF JOINTS IN CONCRETING
1/2" RODS AT 6" CRs
2 ft
6" CHAMFER
3"
6"
3/8" RODS AT 6" CRs IN BOTH DIRECTIONS
1" COVER UNDER LOWER LAYER
CASTING FOR 3" PIPE CONNECTION
VERTICAL RODS 3/8" AT 6" CRs
3/8" RODS AT 6" CRs BOTH WAYS IN BOTTOM.

CYLINDRICAL CONCRETE TANK.

Fig. 2.

The thickness of walls could be reduced to 3 or 4 in. at the top, but the extra cost of shuttering would probably be as much as that of the concrete saved.

A form of casting for making a good pipe connection is shown.

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SECONDARY STRESSES IN MONOLITHIC STRUCTURES AND HOW TO CALCULATE THEM.

By R. J. HARRINGTON HUDSON, B.Eng., A.M.I.C.E., A.M.I.Mech.E., M.C.I., M.Am.C.I., Executive Engineer, Public Works, India.

The importance of the monolithic property of reinforced concrete construction is now generally recognised. To design a monolithic reinforced concrete structure economically a knowledge of the stresses likely to develop in the structure is of first importance.

This article introduces to the Profession what is believed to be a new method of investigating the stresses in monolithic reinforced concrete structures.

The present writer wishes to express his appreciation of Dr. Faber's work in this direction. Dr. Faber may well be regarded as a pioneer of true and real monolithic design amongst reinforced concrete engineers in this country, and although he and the present writer have been working independently along rather different lines, the object in view has been the same and the results agree in many particulars.

Dr. Faber approaches the subject by means of heterogeneous rates (inertia/length), and utilises equations of angular deflection, whereas the present writer prefers to use homogeneous rates, i.e. the pure ratios of (inertia/inertia) and (length/length,) and utilises the equations of the well-known Theorem of Three Moments in a special form.

The chief features of the method employed by the writer are, briefly :—

(*a*) The use of *pure ratios* comparing the mathematical properties of one member with the analogous properties of another in a monolithic structure. These *pure ratios* of (1) inertia moment and (2) length are independent of the units in which the two properties are expressed.

(*b*) The use of a particular generalised form of the equations of the Theorem of Three Moments applied to a continuous beam, and the introduction in these equations of a *qualifier Q* which is governed by the distribution of weight on the beam. The value of this qualifier *Q* may be obtained from a consideration of the bending moments induced at the ends of a *fixed* beam having similar properties of inertia moment and length and carrying the same distribution of weight.

(*c*) The investigations of bending moments in monolithic structures consisting of beams of one span or more monolithic with pillars rising to one story or more by eliminating, for the time being, all direct stresses on the pillars and swinging the pillars into line with the beams, still preserving the monolithic nature of the structures.

(*d*) The construction of simple alignment charts and diagrams, based on the above investigations, from which bending moments may be readily ascertained for all values of the pure ratios of (1) inertia moment and (2) length referred to in (*a*).

In a monolithic reinforced concrete structure the whole or part of the stress to which one member is subjected is transmitted directly or indirectly to other adjoining members.

Each member has the property of *stiffness*.

Stiffness is the converse of flexibility.

Flexibility is measured by the equation of deflection which may be written in the general form—

$$\text{Deflection} = C \cdot B \cdot l^2 / E \cdot I$$

where—

C = a *constant*,
B = the *bending* moment on the member, whether beam or pillar,
l = the *length* of the member,
E = the *elastic* modulus of the structural material,
I = the *inertia* moment of the section of the member.

In this equation of deflection the only expressions which are peculiar to individual members are, the length (l) and the inertia moment (I), and therefore—

$$\text{Deflection of a member} \propto l^2/I,$$
$$\text{and Stiffness of a member} \propto I/l^2.$$

In other words, the *stiffness* of a member depends upon the factors—

(1) *inertia moment*,
(2) *length*.

A comparison of the stiffness of one member with the stiffness of another indicates the influence which exists between the members for imparting stress from one to the other.

There is the familiar case of the beam, monolithic with pillars, the bases of which are fixed in direction, *Fig.* 1.

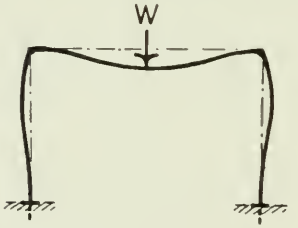

FIG. 1.

The deflection of the beam, when subjected to transverse stress, due to the superimposed weight W, induces bending moments in the pillars. These bending moments are transmitted to the pillars through the rigid right-angled connections between beam and pillars. Provided the connections are unyielding,* the bending moments so transmitted are exactly equal to the negative bending moments at the ends of the beam, due to the stiffness of the pillars and their tendency to fix the ends of the beam in a horizontal direction.

The magnitude of the bending moments induced in the pillars depends upon the relation which each property, *inertia moment* and *length*, of the beam bears to each analogous property of the pillars.

Fig. 2 illustrates diagrammatically the proportional bending moments which the stressed beam induces in the pillars when each of these properties (1) *inertia moment* and (2) *length* predominates in (I) the beam and (II) the pillars.

(1) *Inertia moment.*

I. When inertia moment predominates in the beam the beam resists deflection. As the pillars are relatively slender their tendency to fix the ends of the beam in a horizontal direction is slight. The bending moment diagram of the beam approaches that of a simply supported beam, and the negative bending moments B,B, at the ends of the beam, which are transmitted to the pillars, are small.

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* Extract from *Tests on Rigidly Connected Reinforced Concrete Frames*, III, 28, University of Illinois Bulletin, No. 107. "It is apparent from the action of the frames and from the stresses observed that the stresses and, therefore, the moments were well transmitted from member to member by the connections. From the results it is felt that there is every reason to have confidence in the rigidity of connections in frames that are properly designed," and in which the concrete is sound.

II. When inertia moment predominates in the pillars, the beam, being relatively slender, is now less able to resist deflection. The relatively stiff pillars tend to fix the ends of the beam in a horizontal direction, and the bending moment diagram of the beam approaches that of a fixed beam with comparatively high negative bending moments, B,B, at the ends, which are transmitted to the pillars.

(2) *Length.*

I. When the length of the beam predominates the beam is less able to resist deflection. The pillars, being relatively short, are better able to fix the ends of the beam in a horizontal direction. The bending moment diagram of the beam approaches that of a fixed beam with comparatively high negative bending moments, B,B, at the ends, which are transmitted to the pillars.

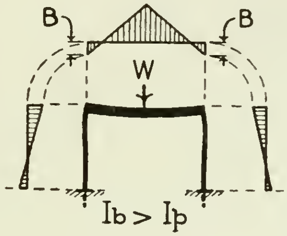
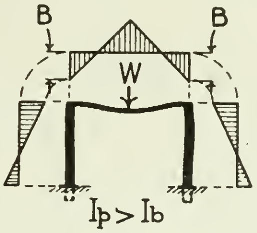
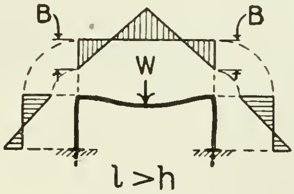
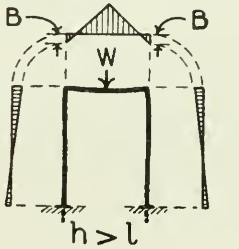
FACTORS OF STIFFNESS	I PREDOMINATING IN BEAM	II PREDOMINATING IN PILLARS
(1) INERTIA MOMENT		
(2) LENGTH		

FIG. 2

II. When the height of the pillars predominates, the beam is relatively short and its deflection small. As the pillars are long their tendency to fix the ends of the beam in a horizontal direction is slight. The bending moment diagram of the beam approaches that of a simply supported beam, and the negative moments, B,B, at the ends of the beam, which are transmitted to the pillars, are small.

Is is clear that, in designing this and other similar monolithic structures, the members should *not* be designed individually without reference to other members of the structure, but rather, the structure should be *treated as a whole,* and each member considered in its relation to and effect upon every other member to which it is connected, directly or indirectly, through the monolithic nature of the structure.

Inertia moments are measured in any lineal units raised to the fourth power.

Lengths are measured in any ordinary lineal units. It therefore seems to the present writer that the simplest and the most logical manner in which the stiffness of any two members, say *A* and *B*, of a monolithic structure can be compared is by the *pure* and mathematically correct ratios of their analogous factors of stiffness—

(1) Ratio of Inertia Moments $= \dfrac{\text{inertia moment of } A}{\text{inertia moment of } B}$;

(2) Ratio of Lengths $= \dfrac{\text{length of } A}{\text{length of } B}$;

and the manner in which stresses in member *A* affect member *B* is dependent upon the values of these two pure ratios.

It is important to note that the above pure ratios are independent of the units chosen. Inertia moments may all be measured in inches, or in feet, or in centimetres, or in any other lineal unit raised to the fourth power. Lengths may all be measured in inches, or in feet, or in yards, or in metres, or in any other lineal unit. The value of a *pure* ratio is not affected by a change of unit.

Using standard notation—

Ib = *inertia* moment of *beam*.
Ip = *inertia* moment of *pillar*.
l = *length* of beam
h = *height* of pillar,
then ri = *ratio* of *inertia* moments = Ib/Ip.
and rl = *ratio* of *lengths* = l/h.

Ib, Ip are measured in any convenient lineal unit raised to the fourth power,

l, h are measured in any convenient lineal unit.

Ib, l, and Ip, h, are inserted on *Fig.* 2 to denote the properties (1) Inertia moment and (2) Length of the beam and the pillars respectively.

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NOTE.—This article will be concluded in the December issue. It must necessarily be brief and only a very small portion of the field open to investigation by the writer's method can be covered. For a full treatment the reader should consult *Reinforced Concrete: A Practical Handbook*, by R. J. Harrington Hudson, shortly to be published by Chapman & Hall.

MEMORANDA.

Abrasion Test for Concrete.—The Engineer of Tests at the Kansas State Agricultural College has been carrying out some investigations with a view to a laboratory abrasion test with a standard apparatus, which would give definite results in comparing concrete mixtures for pavements. Nine-inch spherical test pieces were made and after proper ageing and curing they were submitted to abrasion in a standard brick "rattler." Spherical test pieces were used, as it was considered that they had advantages over rectangular specimens.

The specimens were made of varying aggregates and mixes. The results of the tests seemed to indicate that the method adopted is entirely practicable and possesses several advantages over other tests so far developed. The tested samples indicate the desirability of a coarse aggregate of smaller size than is commonly required for one-course concrete work.

It is believed that the improved wearing value shown by the richer mixes used for the wearing course of a pavement is largely due to the finer coarse aggregate used in such mixtures.

It is not believed that smaller-sized spheres would be practicable. Some 6-in. spheres were cast and tried out with unsatisfactory results.

Water Tanks.—Some elevated reinforced concrete water tanks have been built recently in Germany. The largest of these has a total height of 200 ft., made up of a 164 ft. tower and a top tank 36 ft. high. In addition to the upper tank there is a tank at the ground, the bottom of which forms the footing base for the tower. There are also intermediate tanks. The bottom tank has a capacity of 132,000 gals., and the next succeeding tanks have capacities of 17,000, 53,000 132,000, and 262,000 gals. respectively.—*The Engineer.*

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

CONCRETE FOR HOUSING PURPOSES.

Mr. Irving K. Pond, an American architect, recently read a paper before the National Conference on Concrete House Construction in Canada, in which he pointed out that while concrete has its legitimate uses in this connection, its too general employment was, in his opinion, to be deprecated.

He summarises his conclusions and arguments as follows :—

Imitations.—Concrete has a character of its own ; there is no call to torture it into imitations of stone, wood, bronze, or other material. Details cast in moulds should bear the plastic touch of the modeller, and not the chisel marks of the sculptor.

Economy.—Forms suited to the special purpose should be used. Forms extravagant of labour and materials should be avoided, and should be employed only where duplication can be accomplished without monotony.

Monotony.—Even a good thing ceases to be a good thing when used in excess, and two concrete houses from the same forms, placed side by side, is an excess—such treatment is permissible only in barracks where men are in uniform and drilled into the same line of thought, act, and movement, all individuality being eliminated.

[The argument in favour of selecting the soldier for monotonous surroundings seems rather hard !—Ed.]

Slabs.—Flat slab roofs may at times and in places be appropriate. A general use would be deadly unless counteracted by features the initial expense of which would more than offset the element of economy which alone would serve to call for a wide prevalence of such roofs.

Monolithic Forms.—This method presents advantages in certain types of structures. The appearance of mass and strength is enhanced by monolithic treatment. Openings and corners can be characteristically and ornamentally treated at slight or no additional expense. Houses pre-cast from monolithic forms and transported as slabs or as units are to be looked upon with suspicion as tending to create types and general monotony.

Blocks as Units.—Concrete blocks laid to be effective as units may perform a legitimate æsthetic as well as structural service. Texture and colour can be given them. Their danger lies in exaggerated scale and general uniformity. Stone has the advantage of lending itself to cutting and fitting in length and height without consequent economic waste. The manufacture of concrete blocks should be studied with variety of size as well as appropriate scale in mind. Corners and angles should be true, and crude and rock-faced surfaces avoided.

Blocks as Backing for Stucco.—This is a legitimate field for the use of concrete blocks. Scale need not be taken into account ; neither need such matters as sharpness of corners and angles of crudity of surface. Uneven chipping where blocks are cut approximately to the desired outline presents no obstacle to the perfect finish. Surfaces should be such as those to which the stucco will most readily adhere.

Costs and Permanence.—In a letter from an official of the United States Housing Corporation, these words are found :—" We were satisfied that there were certain types which would produce a good practical house at a very moderate cost, but it appeared to us that this could be done only where the same unit was repeated indefinitely, and our belief was that this would produce a deadly monotony."

As to the monotony, this has already been dealt with ; as to the cost and permanence, or durability, there may be cases where permanent houses would be a drawback in a developing community. There would be very little salvage in a wrecked concrete house, while the wrecking would entail almost as much expense as the construction. Unless a community was well " zoned," buildings of a too permanent nature were an economic waste, even though the initial cost might be the same as for a building of a less permanent character. Where, as in many communities, change is the order of the day, well-constructed buildings of a more temporary nature are desirable. Buildings of a temporary nature can be " fire-stopped " and made safe for occupancy.

[Readers must bear in mind that the article relates to Canada.—ED.]

Fireproof Character of Concrete Houses.—In the letter above referred to these words appear :—" We found that the people who were interested in the concrete house were almost without exception trying to build every part of the house in concrete, including porches and all the trim." This would seem to indicate a deficient sense of humour on the part of the people referred to, as well as deficient vision. I will grant that the designs of many architects who never intended to make a joke of their work are such as to be readily translated into concrete and would not lose in the process ; but a concrete man with a sense of fitness, I call it humour, would not design to effect the translation. I must still warn the enthusiast against excess ; excess in imagination as well as excess in material ; or some of them may wish to make the door-hinges out of concrete after all. Fire-proofness, so to speak, and permanence, are good qualities for which it is possible at times to pay too much.

Methods and Means.—How to make the house reasonably fire-proof, reasonably durable, reasonably attractive and reasonably economical in cost and in upkeep presents a series of problems for the architect and the concrete expert. As an architect I shall receive the findings of the concrete expert, and will make such application of the methods and means presented as may suit the particular case. I will even present the case beforehand to the expert—if it is not already covered—and aid him in his solution. I will even ask him now to present types of floors in structures and finish which are durable, economical, and appropriate to a small house. I will ask the same concerning the roofs, high pitched, low pitched, and flat.

There are many problems to be solved in connection with the design, construction, and location of the concrete house, and I congratulate the concrete and cement interests that they have enlisted the services of so many serious-minded and enthusiastic men in the quest for the best along these lines. I hope that architects of vision and deep feelings may be called upon to co-operate.

THE CONCRETE INSTITUTE ANNUAL DINNER.

The Annual Dinner of the Concrete Institute will be held on Thursday, December 8, at 7.30 p.m. The *rendezvous* will be communicated in a circular shortly to be issued to members giving full particulars of the function; meantime all members are asked to book the date and time, and to make every effort to keep them free, in order that a representative attendance may be secured.

VISIT TO THE PUBLIC WORKS, ROADS, AND TRANSPORT EXHIBITION.

The Public Works, Roads, and Transport Congress and Exhibition, of which the President of the Concrete Institute, Mr. E. Fiander Etchells, A.M.Inst.C.E., Hon. A.R.I.B.A., is an Hon. Vice-President, is being held at the Royal Agricultural Hall, Islington, London, N., from November 17 to 25 next.

By the kind invitation of the Promoters, the members of the Concrete Institute will pay an official visit to the Exhibition on Monday, November 21, at 5.30 p.m.

Tickets for the visit (to any number) may be obtained by members from the Secretary of the Institute, 296 Vauxhall Bridge Road, S.W.1.

ORDINARY GENERAL MEETING.

Members are reminded that the 106th Ordinary General Meeting will be held at Denison House, 296 Vauxhall Bridge Road, S.W.1, on Thursday, November 24, at 7.30 p.m., when the Presidential Address will be delivered by the President, Mr. E. Fiander Etchells, A.M.Inst.C.E., etc.

MEMORANDA.

Concrete Tanks for Oil Storage.—Some very interesting information regarding the use of concrete for oil storage tanks and reservoirs may be gleaned from a little pamphlet which has just reached us, issued by the Portland Cement Association of U.S.A. Quite apart from the illustrations and particulars of construction of such tanks, one is struck, on perusing the pages of this little publication, how extensively such tanks are used in America. From a detailed table at the end, we abstract the following summary: Some 482 such tanks have been constructed and are being used by the large oil companies throughout the United States. These tanks vary in capacity from as low as 1,200 gallons to as high as 337,500,000 gallons. They have been in use for differing periods; the earliest appear to have been constructed in 1907 and 1909 and the report on their present condition is in all cases satisfactory. The greatest activity in this field of construction seems to have taken place in 1918 and 1919. In a later issue we hope to publish some further details regarding the construction of these reservoirs and tanks.

Auckland Main Drainage Scheme.—In a paper read before the Institution of Civil Engineers, Mr. Walter E. Bush stated that in connection with this scheme some large storage tanks have been constructed. The tanks are in three sections, being 1,296 ft. long by 106 ft. wide over all. The average depth of liquid contained is 9 ft. 1 in., and the total storage capacity is 7,800,000 gallons. The tanks have been constructed of concrete throughout, the outer walls being of mass concrete, and the division walls, floor, columns and roof of reinforced concrete.

New Water Tower, Doncaster.—A new water tower is to be erected off Armthorpe Lane, Doncaster, and the design of the Trussed Concrete Steel Company has been accepted for this work.

Wharf at Costa Rica.—A reinforced concrete wharf of dimensions sufficient to permit of the simultaneous discharge of four ocean-going steamers of 3,000 tons minimum at the port of Punta Arenas, on the Pacific coast of Costa Rica, is about to be erected by the Public Works Department of Costa Rica.

Tenders are invited and should be forwarded under sealed envelope addressed to the Dirección de Obras Publicas, San José, Costa Rica, and marked "Muelle de Punta Arenas—Proposición." The envelopes will be opened on December 20.

Some notes on the situation of the port and the possibilities of supplies of certain requisite raw materials for the new work, together with a translation of the conditions of tender, have been received from the Acting British Consul at San José, and may be inspected on application at the Inquiry Room of the Department of Overseas Trade.

THE FIRE RESISTANCE OF CONCRETE AND REINFORCED CONCRETE.

The following (abstract continued from page 662 of our October issue) is from a paper read by Mr. D. W. Wood before the Junior Institution of Engineers, and summarises the details and results of tests carried out by the British Fire Prevention Committee with the aid of grants made by the Scientific and Industrial Research Department. Our illustrations are reproduced from the Red Books of the British Fire Prevention Committee dealing with these tests, and we are indebted to the Controller of H.M. Stationery Office for his permission to make use of these photographs.—Ed.

RESULTS OF AND LESSONS FROM THE TESTS ON PLAIN CONCRETE.

Ordinary Concretes of 4 : 2 : 1 Mixtures.

Natural Aggregates :

Thames ballast as an aggregate proved to be entirely unsatisfactory from a fire resistance standpoint. The results proved that flint as an aggregate or a constituent of an aggregate is capable of even less fire resistance than quartz. Flint has been proved to expand more rapidly and to a greater extent than quartz, and this is borne out by a comparison of the deflection in the centre of the slabs, those composed of flint-pebble concrete deflecting considerably more than those in which quartz is the predominant mineral of the aggregate :—

Slabs.

C 1 Thames Ballast	1·50	with	C 23 York Sandstone	0·75	C 45 Lancs. Sandstone	0·63
			C 41 Tame Gravel	0·87	C 62 Tame Gravel	0·70
C 3 Pit Ballast	1·25		C 43 Tame Gravel	0·88	C 55 Millstone Grit	0·75
C 14 Thames Ballast	1·25		C 44 Nuneaton Granite	0·56	C 60 Tay Gravel	0·50

Gravels.—The other gravels were also unsatisfactory, notwithstanding the variety of their compositions (C. 3, 41, 42, 43, 59, 60, 62, 87).

Sandstones.—Without exception these too proved unsatisfactory as fire resisting aggregates (C. 23, 30, 44, 45, 55, 72, 75, 80).

Limestones.—Some of these showed somewhat better results, but none could be considered satisfactory. Further investigations prove that in the case of limestones fine grained material withstands the effect of heat much better than that which is coarsely crystalline (C. 22, 31, 69, 77, 85, 90).

Granite and Bricks.—Similarly Granite has a considerable proportion of silica in it—in some cases as much as 66 per cent. or even more, and in like manner the material from which bricks are made contains a very large percentage of silica—yet granite has not stood the test so well as bricks, as the grains of granite quartz are larger than the brick quartz. Of course, too, the fact that bricks have been subjected to fire when being made is another factor.

Igneous Rocks.—Of these it is more difficult to speak. Those with the finest grain apparently have the best fire-resisting properties.

Of the eleven tested, Nottingham basalt (C 57) proved to be the best, with trachyte (C. 70) a good second, whilst blue basalt or Troon stone (C. 73) was the worst. The whinstones (C. 21, 32, 46, 61) and Rowley Regis "granite" (C. 56) followed the trachyte, after which came Irish andesite (C. 58), whilst the true granites (C. 71, 78, 79) did not behave at all well.

Nottingham basalt came from quarries near Matlock, and trachyte from Prestonkirk, Haddington.

It was thought that as Thames ballast was in such demand as an aggregate and in view of the strength of the concrete made with it, that if it could be mixed with any other aggregate that had exceptional good properties from the conductivity standpoint a serviceable concrete might result. Nottingham basalt was found to meet these latter conditions and a slab (C. 84) was therefore made in the proportions of 2: 2 and 2 of sand and 1 cement, but the result was unsatisfactory.

ARTIFICIAL AGGREGATES:

Slags.—These behaved well, particularly the two slabs made from the Kettering slag (C. 25, 28—the other was C. 76).

Bricks (Stock and Fletton).—If broken old bricks are used they must be thoroughly well cleaned from all lime, mortar and other rubbish. The concrete made from the brickbats taken direct from the brick works proved to be of exceptional sterling qualities. Further reference will be made to this aggregate which was tested in several varying proportions (C. 4, 6, 7, 9, 26, 27, 33–40, 53, 89, 91).

Fire Brick.—This material stood well, but it is not likely that it will be used in concrete generally owing to the small quantity available and its cost (C. 88).

Burnt Gault Clay.—This aggregate as well as the broken brick proved to be the best of this series of tests—two slabs were made, one of burnt gault clay, sand and cement (C. 74), and the other solely of the clay and cement (C. 83) and this latter mixture proved to be a better concrete than the former. The gault clay was dug at Burham in Kent, and the Associated Portland Cement Manufacturers state that it is burnt in a Hoffman kiln and ground in a pan mill.

Coke Breeze.—Several slabs had " fine " coke breeze in lieu of sand (C. 5, 8, 49, 50, 54) and these proved satisfactory, whilst those with sand as a " fine " aggregate was not quite so good (C. 47, 48).

Pan Breeze, Clinker.—These gave quite as good results as plain concrete slabs. (Pan Breeze C. 82, Clinker C. 24, 29, 51, 52, 81, 86.)

Application of Water.—The slabs that were not subjected to the water test after the fire test did not in the long run acquit themselves better than the others, notwithstanding the fact that, comparatively, but little erosion occurred during the fire test, the water test being chiefly responsible for this effect. It would seem that the slabs on cooling without the application of water became more susceptible to collapse, as three of the twelve slabs not subjected to water collapsed during cooling, whilst only one of a similar twelve subjected to the water test collapsed, and of a further thirty-eight only two collapsed.

OTHER CONCRETE MIXTURES.

Having dealt with those plain concrete slabs of the series which were made of the recognised proportions of 4: 2: 1, and subjected to both fire and water tests and fire only, the plain concrete slabs of other proportions and those to which a " protective " covering had been given must be described.

Plain concrete slabs made of a rich concrete, that is a concrete made with more cement, whether with Thames ballast 3 : 2 : 1 (C. 16), 3 : 1½: 1 (C 15), or broken stock brick 3 : 2 : 1 (C. 36), 3 : 1½ : 1 (C. 35), or Coke Breeze 3 : 2 : 1, both with sand (C. 48) and coke breeze as the " fine " aggregate (C. 58) or furnace clinker (C. 52), did not tend to prove that the general assumption that a concrete richer in cement affords increased fire resistance is correct, notwithstanding that from the purely mechanical tests the concrete appears stronger.

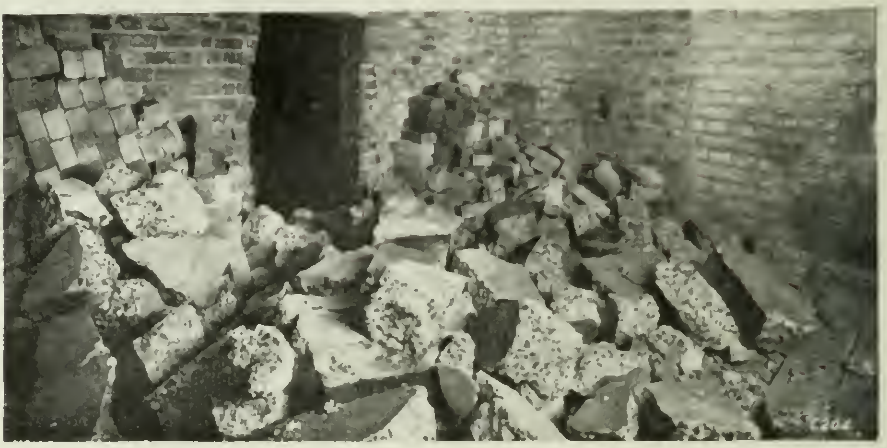
A slab made entirely of fine coke breeze in the proportions 5 : 1 proved very satisfactory (C. 54).

Some tests of peculiar mixtures such as Thames ballast with fine brick (C. 13), broken brick and fine brick (C. 33), broken brick and fine coke (C. 53), clinker and fine coke 3 : 2 : 1 (C. 52), and clinker and fine coke 4 : 2 : 1 (C. 51), proved respectively—very unsatisfactory, good, very good, good, and fair.

Ten other tests of Thames ballast with varying protective coverings mostly gave unsatisfactory results, only one (C. 17) with 2 in. coke breeze concrete covering being satisfactory, and that was very good (C. 17, 18, 19, 20, 63, 64, 65, 66, 67, 68).

Four slabs of broken brick were similarly protected, and these gave much better results (C. 3, 7, 38, 39, 40).

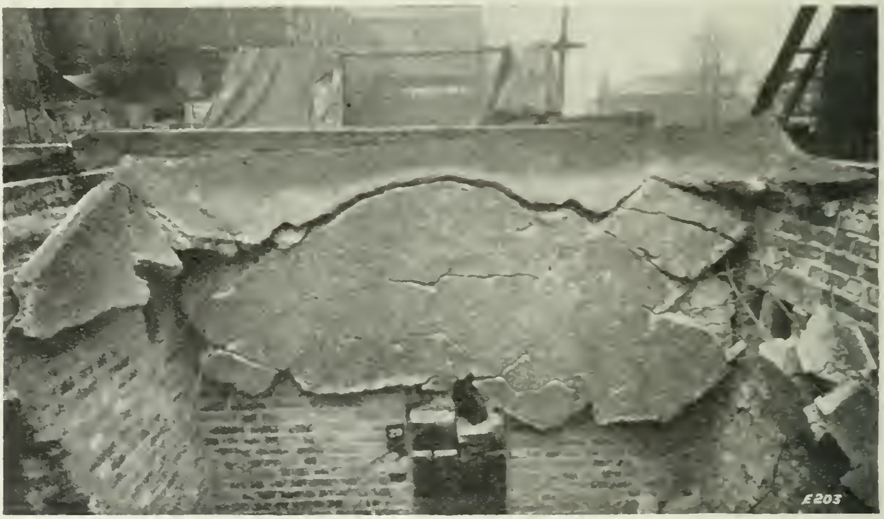
The protective coverings consisted of ½ in. ordinary plaster, ¾ in. fireclay plaster,



From Red Book 216.

PLAIN CONCRETE SLAB, C. 27. BROKEN BRICK, 4; SAND, 2; CEMENT, 1.

Slab fell whilst load was being removed after test. N.B. The broken brick as delivered comprised 37 per cent. of rubbish, 10 of flint and 53 of brick. This was picked over and an analysis of the material used gave 11 per cent. of mortar, 11 of flint pebbles, and 78 of brick.

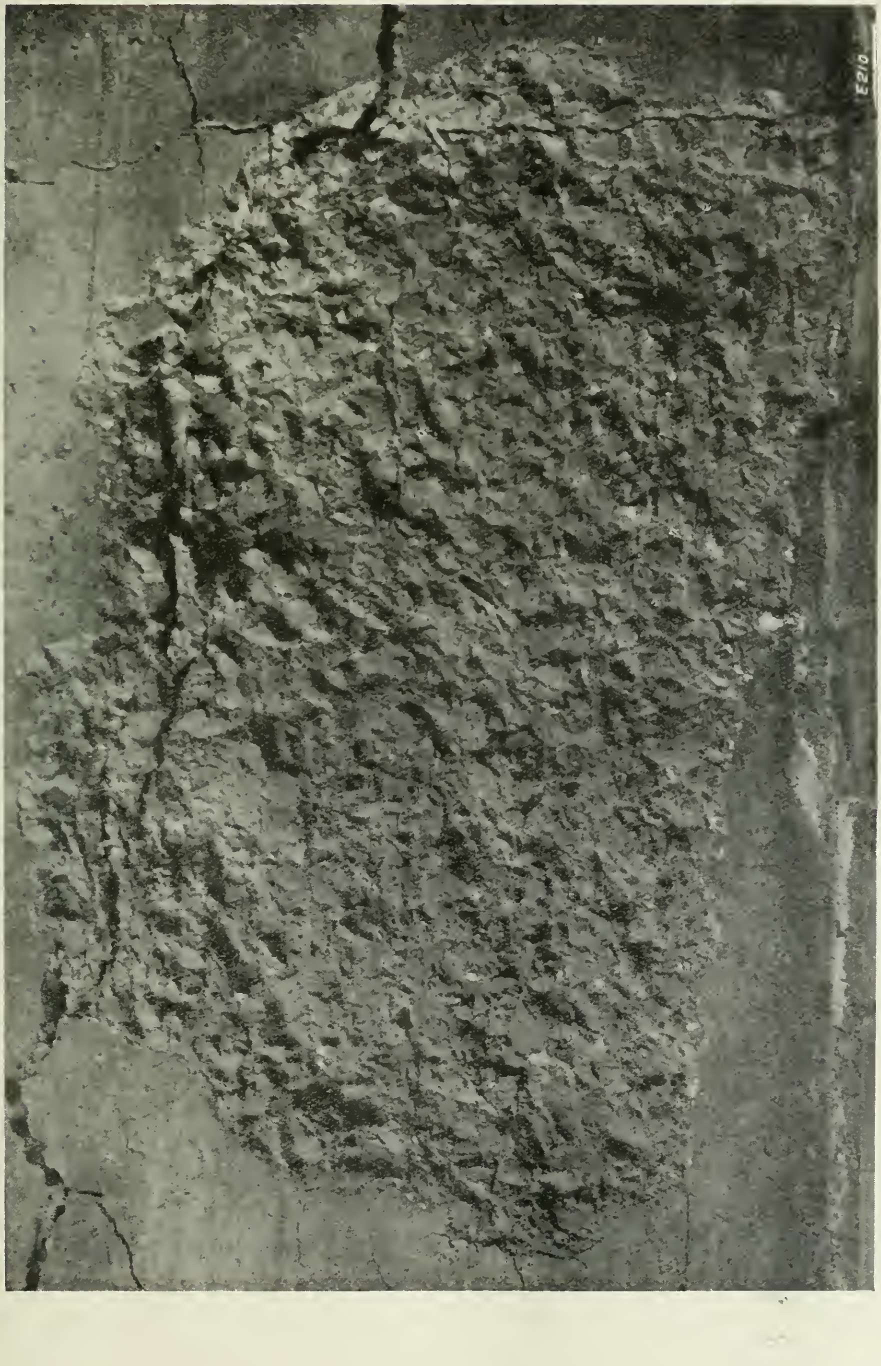


From Red Book 232.

REINFORCED CONCRETE SLAB, R.C. 29. PAN BREEZE, 5; CEMENT, 1.

Slab fell after 191 minutes of test; maximum temperature, 1900° F.

and concretes of 1 in. coke breeze, 2 in. coke breeze, 1 in. pan breeze, 1 in. clinker, 1½ in. stock brick, 1½ in. coke breeze, 1½ in. pan breeze. All these slabs were in the aggregate 5½ in. thick, and the protective concretes were made of " fine " stuff mostly in the proportions 5 : 1.



From *Red Book* 216

PLAIN CONCRETE SLAB, C. 20. YORK SANDSTONE, 4; SAND, 2; CEMENT, 1.
Slab fell whilst load was being removed after test.

In these tests the two concretes did not as a rule break away from one another.

A striking feature deserving special comment was the very satisfactory behaviour of the supporting girders between the slabs of plain concrete. These were rolled steel joists of discard steel each 6 in. by 5 in. weighing 25 lb. per ft. lineal, the ends being built into the side walls of the huts with a bearing of 8 in. at each end and a space of 1 in. left between the end and the brickwork. Each joist was encased with coke breeze concrete (5 : 1) so as to give a minimum covering to the joists of 2½ in. with overall measurements of 11 in. × 10 in. This covering was protected with fire-clay plaster composed of Portland cement 1 part, fire-clay 1 part, washed sand ½ part, and fine coke breeze 2 parts. These girders were used for five successive tests, only the fireclay plaster covering having to be repaired, and another set for six successive tests.

Reinforced Concrete.

The tests with slabs or floors of reinforced concrete must now be described.

The floors were all 10 ft. 0 in. × 10 ft. 0 in. in the clear, and all formed the roof of the testing chambers with the fire on the under side. All the floors were loaded with 168 lb. per ft. super. with the exception of two—R.C. 9 and 10—which carried 280 lb. per ft. super. The fire tests were for four hours and water was subsequently applied for five minutes. It is probably superfluous to state that the *fundamental principle* underlying the various applications of reinforced concrete is, that whereas steel is extremely strong in tension, concrete is strong in compression but comparatively weak in tension. That is to say concrete will resist an enormous crushing load, but it is brittle and will break across if loaded as a beam. All the concretes were tested at Kirkcaldy Laboratory under the direction of Dr. Gulliver, and the average co-efficient of the bending strength of fifty-nine specimens expressed in a percentage of the crushing strength may be said to be fifteen. Reinforced concrete may therefore be described as cement concrete strengthened by steel rods in such a manner that the compressive stress will be taken by the concrete and the tensile stress by the steel. The shear stress is taken partly by the concrete and partly by the steel. These stresses are produced in the material by the weight of the material itself, by the action of external loads, and in some cases by the force of the wind.

From Red Book 238.

Reinforced Concrete Slab. Showing Method of Loading Slab.

The illustration shews slab R.C. 31. Bargate Stone (calcareous sandstone) which collapsed after 88 minutes of test. Maximum temperature, 1600° F. The other slab is R.C. 32. Teign " Granite " (Diabase) collapsed after 96 minutes of test. Maximum temperature, 1540° F.

CONSTRUCTION OF THE SLABS.

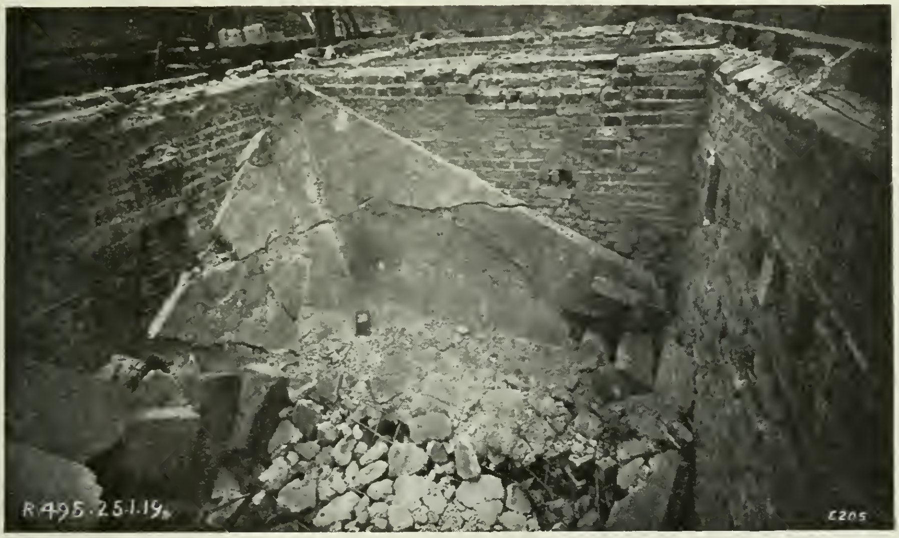
Similar remarks as to the general arrangements of the tests which were made in the case of the plain concrete slabs, apply to this series, and in addition the following comments must be added :—

The slabs or floors were mostly made on the ground and when ready for testing hoisted on to the top of the huts.

Two methods were adopted for placing the reinforcement :—

At first, for slabs R.C. 1–25 the " cover " of concrete was laid and tamped even, then the grill of reinforcement was placed on the concrete, the remainder of the concrete being subsequently filled in. Care was taken that none of the first concrete " set " before the last was added. Those slabs having protective covering were dealt with in a similar manner.

The second method was to temporarily support the grill of reinforcement by small wood blocks, and then tamp in the concrete under, around and over the grill, as it had been noticed that there was a slight tendency for any cleavage in the concrete to be more apparent on the line of the reinforcement, and it was felt that there might be a possibility of the first or " cover " concrete setting before the other concrete was added.



From Red Book 234.

REINFORCED CONCRETE SLAB R.C. 28. TROON STONE (AYRSHIRE BLUE BASALT—A CRYSTALLINE DOLERITE), 4 ; SAND, 2 ; CEMENT, 1.

Slab fell after 184 minutes of test ; maximum temperature, 1870° F.

REINFORCEMENT.

It was decided that no proprietary form of reinforcement should be used in the tests, consequently the steel was in the form of round rods $\frac{3}{8}$ in. diameter, and the design chosen was that of a rectangular grill.

The grill of the reinforcement was made to one main design, but necessarily modified for the different calculations involved through the various aggregates used and loads carried. Thirty of the sixty-two were made as follows : $\frac{3}{8}$ in. steel rods, 11 ft. 3 in. and 9 ft. 3 in. long, were placed alternately, the spacing of the upper layer of the rods being 4·30 in. centres and the lower 5·72 in. centres. Alternate cross rods were wired together with two pieces of 15 S.W.G. wire $5\frac{1}{2}$ in. long. The ends of the rods were fish tailed.

(*To be continued.*)

SOME IMPRESSIONS OF CONCRETE ON THE WESTERN CONTINENT.

By A. DRYLAND, M.I.C E., County Engineer of Middlesex.

Introductory.

A RECENT journey extending over a period of some five weeks through Canada and the Eastern States of America, has left a strong impression on my mind that engineers on the Western Continent have developed the uses of concrete to a far greater extent than would be observable on a similar journey in England. I have no doubt there are good reasons to account for the dissimilarity, and among the first is probably our innate conservatism arising from our old civilisation, the natural inclination to exploit methods pursued by our forefathers rather than to break new ground. Our development, although in many respects well ordered and persistent, is inclined to be slow, and we follow very largely in traditional courses. Although residents of both Canada and the United States are beginning to show some veneration for what they consider old buildings in their territories, they are far more ready to scrap and build anew than we are. Moreover, their scope for development is enormous, and they are constantly having to design large scale operations of a utilitarian character, and it is utility, if I have gauged them aright, which is the master thought controlling their designs, although they by no means ignore the desirability of grace and beauty, and I think their more recent work of every kind indicates an increasing desire for beauty. Design, naturally and quite properly, is guided by consideration of the material available, and in a country not well provided with stone it is hardly to be expected that masonry construction would prevail. It is fortunate for the development of the world that Portland cement has made possible the utilisation of apparently unpromising material for the erection of large structures, and that, with the assistance of steel, these structures can be formed on lines which provide great strength without undue massiveness. I travelled altogether nearly 8,000 miles on the Western Continent, and concrete was in evidence everywhere : in factories, silos, bridges, viaducts, sewers, culverts and roads, even down to lamp and sign posts. Graceful design and surface treatment, giving fine textural effects, rendered many of these works things of beauty as well as of strength. One form of surface treatment which was especially striking in ornamental lamp and sign post standards and in panelling, was the removal of the mortar from the face of a small granite aggregate. In some cases this was treated in a manner which gave the appearance of a polished granite ; in panels in bridge work it was left rough like a scabbled granite, and gave relief to the usually somewhat flat surface of concrete construction.

The Effect of the Motor Car on Road Construction in America.

The primary object of my visit was to see roads, and I suppose in no other part of the world does concrete enter so largely into road construction. Roads, as we understand them, are a comparatively new thing in America ; except in the cities, the need for them was not felt until the development of the motor industry. Railways were the basis of development, and roads have only recently been deemed a necessary corollary. Distances between towns were great, and they were all connected by railways. Access to a railway was the main consideration, and if there was a track sufficiently solid to allow the crops to be hauled to the stations all necessary requirements were deemed to have been met. But the motor car has changed all that, and now the fortunate owners (and an unprecedentedly large proportion of the population are owners) want to be able to travel in all directions, and to haul their produce direct to market without being restricted to the rail.

In this country, long before the railways were thought of, we had been dependent upon roads for the handling of our commerce or for pleasure travel, and there are few parts where something in the nature of a firm road did not penetrate. This goodly heritage we have been able to develop, strengthen, and utilise with more or less success to carry our modern traffic. America had until recently few macadamised roads, and really first-class macadam is only available here and there in a huge area. Gravel of sorts is more plentiful, although by no means equally distributed. When the demand came for roads it did not mean, as in our case, development, but practically entirely new construction, and engineers quite naturally and properly concluded that a firm foundation was the first and most important consideration, and largely "plumped" for concrete as the most practicable proposition. In the cities they already had concrete foundations for their wood, granite sett, brick or asphalt surfaces, and to a considerable extent they have laid concrete foundations and bituminous coatings on important roads in open country, but where hundreds of thousands of miles had to be dealt with it was not practicable to construct everywhere so expensively.

Unsurfaced Concrete Roads.

Some of the road engineers were convinced that good concrete would satisfactorily sustain the traffic without any form of covering or surface treatment, and for the last twelve years they have pursued this policy until it is now claimed there are 20,000 miles in existence. I have inspected many hundreds of miles of these roads, and can testify they have given, and are giving, good service under the conditions of traffic which prevail. Experience has taught them that the early thicknesses of slab, which were in some cases as low as 4 in., were insufficient, and to-day a minimum is 6 in. at the sides and 8 in. at the centre, some 7 in. to 9 in. and even 8 in. at the sides to 10 in. at the centre. The bulk of the work has been entirely unreinforced, but as heavy units of traffic tend to increase in numbers it has been thought desirable in some States to utilise steel reinforcement. In Pennyslvania they are adopting a mesh reinforcement very similar to that which is frequently used here, at 2 in. below the surface; in Illinois they are placing a steel rod about 6in. from the outer edge of the slab, and where a centre joint is formed rods are used at intervals to connect the slabs so divided.

The Effects of Expansion and Contraction.

As might be expected when large areas of concrete are exposed so as to feel the full effects of ranges of temperature extending from 40° Fahrenheit below zero to a sun heat of about 135°, the effects of expansion and contraction are in evidence in the form of cracks. Chiefly these are transverse, but where widths are over 12 ft. there are occasionally extensive longitudinal cracks. How far these are due to actual temperature changes, or to what extent they are due to swelling and shrinking of the subsoil, is a matter which is being closely investigated. I am inclined to the opinion that the longitudinal cracking is almost entirely due to the latter cause, although recent observations during the hot weather tend to show there is some corrugation of the slab from powerful sun heat. As regards the transverse cracks, I think they are inevitable, having regard to the changes which must take place in length corresponding to temperature. It is common practice to make provision against this by inserting a bituminous cross-joint. The early practice was to insert them every 25 ft., but as it is difficult in practice to avoid slight differences in level, which set up oscillation, the tendency is now to put them at longer intervals, such as 50 and 60 ft., and some have gone still further and now, where reinforcement is used, only put in joints on re-starting work, and these may be as much as 300 ft. apart. It is certain that transverse cracks will show themselves in such lengths, but as both joints and cracks are filled with tar or bitumen, and one is not much more difficult to treat than the other, some engineers say they prefer the cracks to the joints. The filling material spreads on either side of the actual crack or joint and is unsightly, but with proper attention does not affect the smooth travel or lead to any serious deterioration.

Nature of American Traffic.

The traffic is mostly of the fast and light variety, although "motor trucks" are increasing; horsed vehicles are comparatively rare, and the traffic as regards wearing effects may be considered as all rubber-tyred. The surface wear on the concrete appears to be extraordinarily small, and pot-holing or deterioration by traffic is very little in evidence except on some of the early pavements, which were not only thinner, but probably much more inefficiently constructed, than those of the present day. Slab weakness at the edge is indicated generally by triangular cracks at a joint; I saw quite a lot of this on a few roads, and it is this form of defect which has led to bar reinforcement.

Conclusion.

Speaking in general terms, bare concrete in America has afforded, and is affording, excellent service in giving a firm, hard, dustless road, on which high speeds are possible. Whether a great increase in the unit weight of the vehicles, or a greater proportion of steel tyres, would materially affect their life I am unable to determine, but I should say it would. If that proves to be the case they will still have a solid foundation left so their expenditure has not been wasted.

I saw a great deal of work under construction, and can bear testimony to the care and skill exercised in securing good work. Every part of the material is tested before use; sample cores are cast of the concrete, and further cores are later extracted, and both are subjected to compression tests, and strengths compared. Every State has good laboratories, fitted with every known apparatus for testing.

The concrete mixtures are rich, varying from 1–1–3 to 1–2–4, according to voids. Sands are not only sieved to determine grades, but are tested chemically, as in certain parts injurious ingredients, particularly alkali, are found to affect the cement.

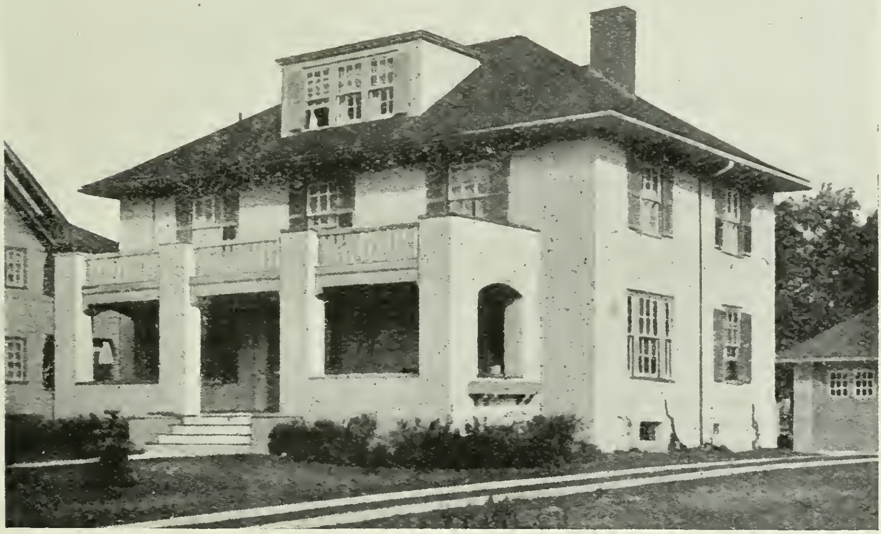
The plants used are very complete, including large batch mixers, machine tampers and finishers, and up-to-date appliances for obtaining good work and speed in laying. The whole organisation for feeding the plants and laying is very carefully thought out, machinery being used for almost every operation. Great attention is paid to the necessary time for mixing and to the addition of the necessary quantity of water, and as to the time for admission, the object being to use only the minimum quantity to allow a good surface being obtained. All these details are important if the best results are to be attained in the use of concrete for roads, and American engineers, by careful specification and careful supervision, are certainly obtaining excellent work. It is probably largely due to the scientific way in which they have studied concrete road construction that such good results have been attained.

MEMORANDUM.

Concrete Proportioning Tests made at Washington University.—In a thesis presented for the Degree of Bachelor of Science in Civil Engineering of Washington University, R. E. Salveter and E. J. Schewe investigated some of the current methods of proportioning concrete, and arrived at the following conclusions: The colorimetric test for organic impurities in sand does not furnish an accurate basis for determining whether or not a sand is unfit for use in concrete. The slump test apparatus is very unreliable, especially in leaner concrete mixtures. There is need for investigations to disclose whether the consistency of concrete is dependent upon the surface area of the aggregate or upon some function of the fineness or grading of the particles. The water content in concrete is the most important single factor influencing strength, though the effect is more pronounced in early ages. The water-cement ratio has proved the most satisfactory of any of the methods for considering the water content of the concrete mix.

AMERICAN CONCRETE DOMESTIC ARCHITECTURE.

From time to time examples of American domestic architecture, executed in concrete, have appeared in these columns. We still feel, however, that both the quantity and quality of this transatlantic work is, for the most part, unknown in England. Here, the use of concrete for the finer type of domestic work is a somewhat rare occurrence, generally resorted to only where difficulty is anticipated in procuring other materials. In America it is used because architects realise the merits of the material, which they understand both scientifically and æsthetically, obtaining results from its employment which excel both in scope and in execution. With the view of familiarising our readers with some of these achievements, and of stimulating the somewhat otiose interest of the architectural profession, we propose showing from time to time examples of American work, accompanied by a few critical notes.



An American Monolithic Concrete House.

The monolithic house is constructed by means of shuttering ; it is, therefore, to be expected that in order to keep the forms simple, the house should be designed with as few irregularities as possible ; salient and re-entrant angles must be minimised and the walls should be carried up evenly to a plate level, which does not vary. Fortunately both England and America abound in suitable prototypes. The eighteenth-century tradition is the one upon which American domestic architecture is founded, and it is the tradition of classical formality modified through usage and transportation. It is a composition of simple units, and still bears traces of its stone origin (although the theory of the origin of the Doric order from an earlier timber prototype has its adherents). The example of American domestic architecture which we show this month is directly traceable to these origins, and, on the whole, the material is eminently suited to the design. There are, however, grave defects in the composition, which it would be foolish to overlook: The unpleasant heaviness of the veranda, the introduction of timber elements in the lintel construction and in the dormer.

One of the greatest advantages of reinforced concrete is its great strength, in both compression and tension, the combination of the two materials complementing each other to achieve this result. These enormous veranda piers, which so detract from the harmony of the composition, are therefore unnecessary; and a lighter treatment, more suggestive of the material, might have been employed with advantage. The large dormer window, to which some exception has been taken, is, of course, the survival of an earlier colonial tradition of timber construction, but in juxtaposition to the plain and more solid wall surfaces below, the contrast is not pleasant. The proportion of voids to masses is good, and the whole building possesses a stately dignity which is one of the most valuable qualities of good architecture.

Although no information is available as to the treatment of the wall surface, it may safely be presumed that both texture and tone have been obtained, for in this American concrete experts have been particularly successful, and there is no reason why they should not be emulated by their English colleagues, who may then be persuaded to exploit this material for domestic work.

MEMORANDA.

National Hydro-Electric Power Stations in Lower Austria.—The fall of the River Erlauff, a tributary of the Danube, has recently been harnessed. The catchment area is 29·3 sq. miles, 90 per cent. of which is situated at a height of 2,600 to 4,000 ft. above sea level. The average rainfall amounts to 55–63 in. annually, although periods of low water occur late in the summer and during autumn.

A 115 ft. high arched concrete wall 85 ft. wide at the base and 10 ft. wide at the top has been constructed across a natural valley to form a reservoir 57 acres in extent. The length of the wall at the top is 262 ft. and the volume 28,800 cu. yds. of Portland cement concrete. The storage capacity, which is 60 million cu. ft. (374 million gallons) when filled to within 16 ft. of the top, and 99 million cu. ft. (616 million gallons) when full, is sufficient to augment the minimum quantity of water daily during a drought of three months' duration with 50 per cent. The flow from the reservoir during high water is drawn through the old river bed, entirely separate from the reservoir dam, and thence through a circular tunnel 16 ft. in diameter having a total height of 69 ft. from the foundations to the crown, the arch of which has a thickness of 4 ft. 7 in. The interior is lined with granite blocks, whilst the exterior consists of rubble masonry and the central part of cement concrete. A cylindrical weir 21 ft. in diameter controls the flow of water to the tunnel, the foundations of which contain a drain 3 ft. 3 in. by 5 ft. 3 in., used for emptying low-level water during construction of the tunnel.—*Technical Review.*

Concrete Headgear Frames.—Two reinforced concrete headgear frames and heapsteads have recently been completed at the Harworth Main Sinkings by Messrs. Barber Walker & Co., Ltd. The structures are identical in design. The two shafts are 200 ft. apart from centre to centre, and the height of the main pulley wheel from the ground is 100 ft.

Concrete Signal Posts.—We learn the South-Eastern and Chatham Railway are replacing their wooden signal posts at Welling in Kent by standards made of reinforced concrete.

CONCRETE COTTAGE BUILDING.

HOUSING SCHEME AT WEAVERHAM, CHESHIRE.

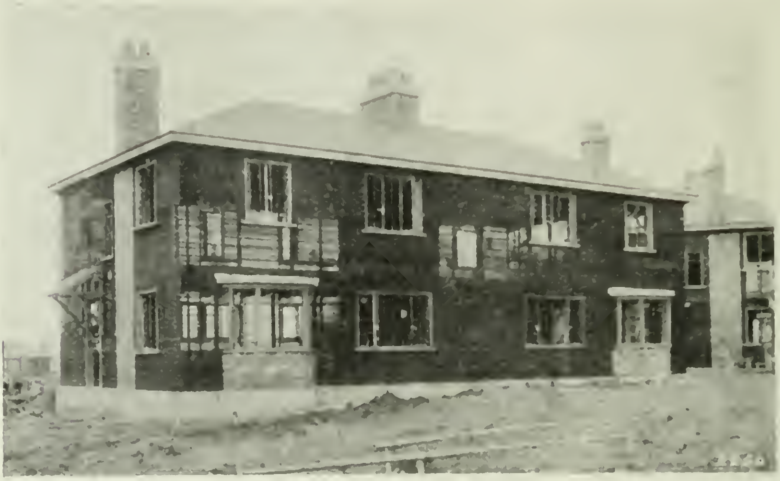
The scheme at Weaverham is a large one, comprising some 250 houses. Over one hundred of these are in various stages of construction and the whole of this work has been executed in six months, with only 160 men. Only by the use of concrete can such results be obtained. The method of construction is one which is rapidly gaining favour, consisting of Hy-Rib metal lathing on a steel frame.

As an example of organisation—and proper organisation is the key to success—this scheme is of particular interest, and may, therefore, be worth setting out in detail for the benefit of others. The method of organisation is that of quickly operating gangs following, as it were, in each other's trails ; each specialised in its particular job, and working with the precision of an army machine-gun or cable-waggon team. The first gang prepares the ground ; it is followed by gang number two, which erects standardised retaining boards for the concrete foundation. The next gang fills in the foundations and prepares the ground floor raft to receive the steel framework. On its heels appears the erector gang which completes the framework for a pair of houses in one working day. In quick succession appears the Hy-Rib gang, followed by the roof and wall concretors. The tiling or slating can now be done at leisure, for the building is covered in and the remaining trades can follow on and work under shelter. In these days when the question of paying for wet time is being mooted, the value of such an arrangement will be readily appreciated. The processes above described represent about four or five days' work, unskilled labour having been so far exclusively employed.

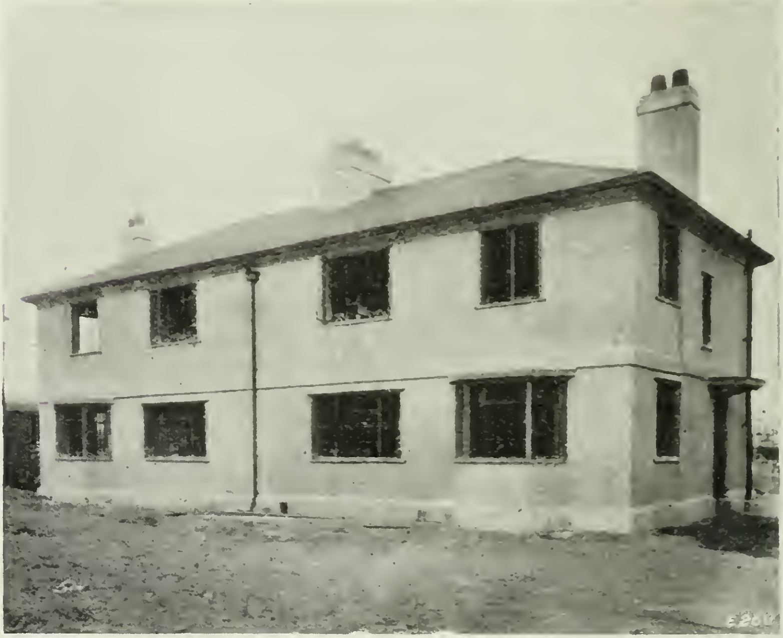
The joiners' department, meanwhile, is working concurrently with these gangs, making the standardised joinery, which must, of course, be fixed to the steel structural members before the Hy-Rib and concrete gangs proceed with their work. Likewise the bricklayer is building up the stacks from off the concrete raft.

Another advantage, arising out of what has already been said, may be noted. Although at the moment it cannot be said that there exists a shortage in labour owing to the Government's utter abandonment of its great housing scheme, nevertheless it is devoutly to be hoped, both for the population generally who remain disgracefully housed and for the building trade, that there may come a period of activity. Then it will be that labour will once more be in a position to pick and choose, and it will quite naturally select schemes upon which work will be able to proceed independently of the weather, so that whether or no wet time is to be paid for, the scheme which permits of continuous work possesses advantages that must appeal alike to employee and employer. A saving of time and money is effected by the ability to use house carcases for sheds, and by the avoidance of scaffolding. The volume of material to be handled is less than in a brick house, the exact amount depending upon the contiguity of suitable aggregate, but the differences may be taken as approximating to 33⅓ per cent. And transport costs are a large factor in building, thus this saving becomes a matter of some import.

As for the architectural merit of these houses, we have expatiated upon similar ones on other occasions. It must not, however, be thought that the adoption of this method of constructon must necessarily be limited to a few definite types of houses. Standardisation in architecture, as in all other commodities, tends to cheapen production, and this constitutes an excellent reason for adhering to a few well-designed types. Such adherence is, of course, entirely a matter of expediency. The method of construction is sound and simple, and it is quite patent that a steel frame can be designed to meet any requirement, and that it can be covered with Hy-Rib reinforcement. It is not a method of building



Houses ready to be Concreted.



View of Finished Houses.

that lends itself to profuse irregularities of form and outline, but then the task of a successful architect is to obtain harmony between his design and the material in which it is to be executed. For a certain type of axial formal planning—a classic rather than a romantic tradition—the method of construction is particularly suited.

SOME HOUSING EXPERIMENTS AT HATTON, WARWICKSHIRE.

An interesting example of the possibilities of concrete block construction is afforded on the Warwickshire estate of Colonel T. Marriott, at Hatton, some five miles from Warwick, and seventeen miles from Birmingham. Retiring after serving with distinction in the Great War, Colonel Marriott made his contribution towards solving the housing problem at home. There were no cottages available for the workmen on the estate which he bought at Great Pinley, but having plenty of sand and gravel on the spot—thirty to forty feet deep—he decided to build some experimental houses in concrete. Like most amateurs he had to buy his experience, adopting one untried system to his cost; but soon discovered that with blocks on the continuous cavity principle he was on safe and profitable ground.

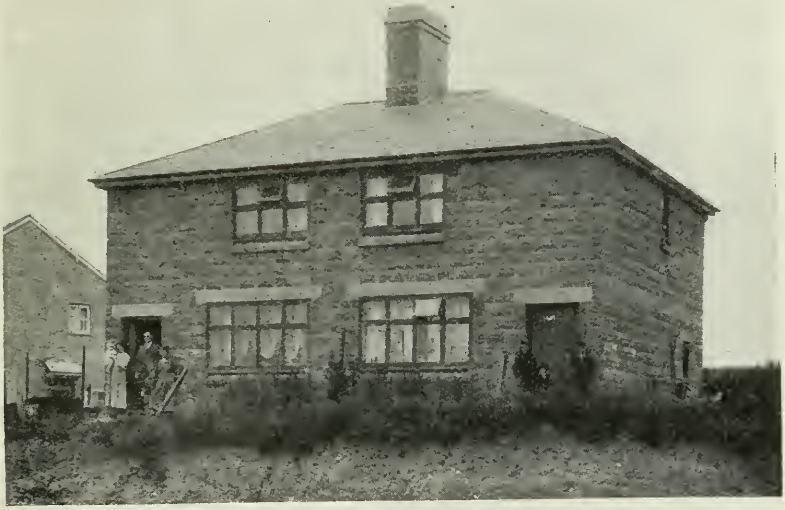


Fig. 1.

While speculative building on the old lines became impossible on account of prohibitive costs, Colonel Marriott, with no previous experience to guide him, was able to build and sell at a profit. He put up his first pair of cottages in 1919 for £1,150 the two—saving at least £50 a house as compared with the estimated cost of building with any other material. They are shown in *Fig.* 1, standing a little way back from the gravel pit out of which, together with a colony of other cottages, they have literally been dug. One of his first two cottages he sold to St. Dunstan's for a blinded soldier, who now lives there with his family and runs a successful poultry farm.

Another interesting experiment on this estate is a detached double-fronted house (see *Fig.* 2) which the foreman and his wife have built for themselves in their spare time. Starting on August Bank Holiday last year, and making the most of their evenings until the following October—when serious operations had to be suspended until the spring, they have now nearly reached the end of their labours. "The Elms"—a substantial, rock-faced house of two storeys, with three reception rooms, four bedrooms, and the usual offices—should soon be ready for occupation.

The blocks used on all these dwellings are made on Winget machines, and the Chain Spade Mixer was used for making the concrete.

Birmingham, where the shortage of houses is acute, is beginning to discover the attractions of Colonel Marriott's little colony. Practically adjoining Hatton Station it is an easy run into the city, and standing on a plateau between 400 and 500 feet high, commanding views of four counties, it is one of the healthiest sites imaginable. Most of the houses are of the bungalow type, with the latest labour-saving devices, and are designed by Mr. Malvern J. Harvey, of Stratford-on-Avon.

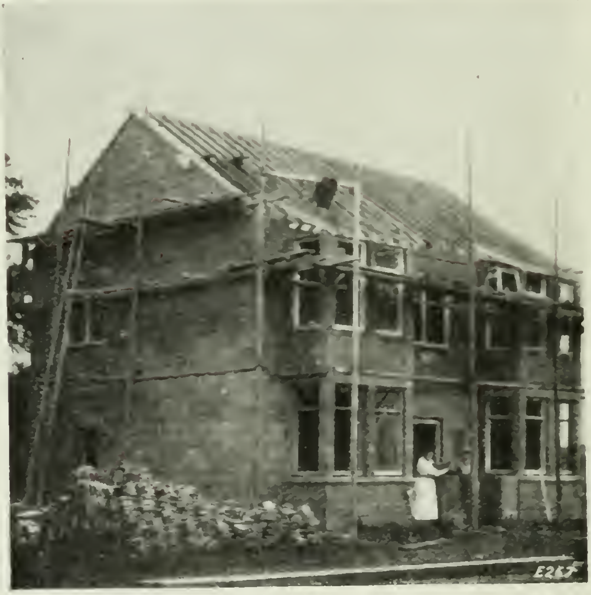


FIG. 2.

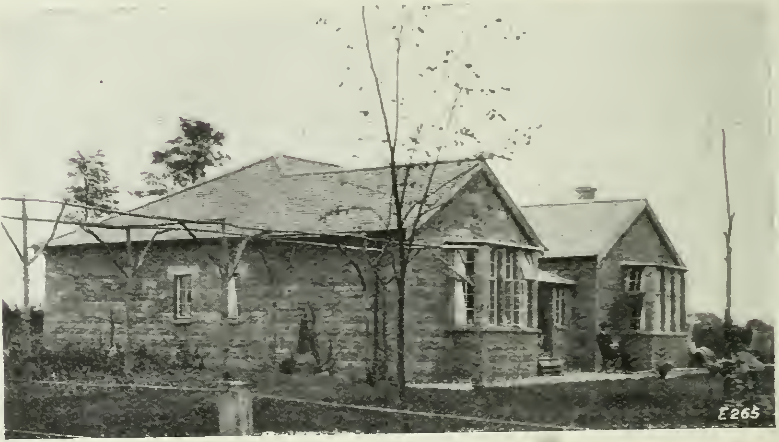
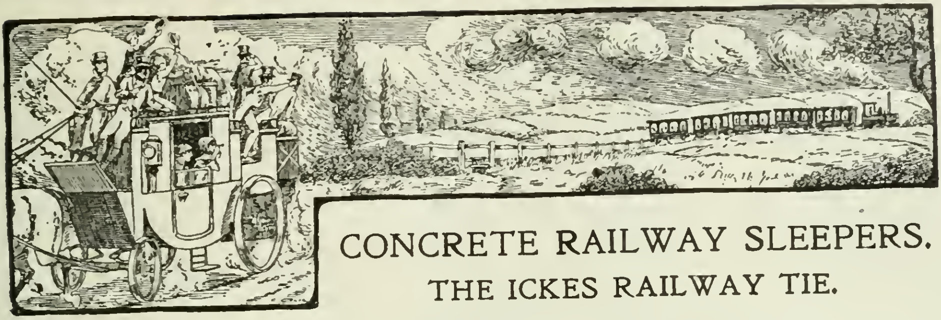


FIG. 3. A BUNGALOW.



CONCRETE RAILWAY SLEEPERS.

THE ICKES RAILWAY TIE.

The use of concrete for railway sleepers has been frequently referred to in these pages, and the following particulars and illustrations from our contemporary "Concrete," U.S.A., may be of interest as indicating the development that is taking place in this direction.—Ed.

The Ickes reinforced concrete railroad tie is designed in three types to provide for the different conditions to be met in track work. Its main feature consists of lateral enlargements of the tie immediately under the rail, making the longitudinal support of the rail at this point 21 in. instead of 8 in. for the wooden tie. This enlargement is 9 in. wide, increasing the lateral resistance to spreading of rails, especially in curves, nearly three times that of an ordinary wood tie, as far as concerns the direct pressure on the ballast.

To avoid the danger of breaking in the centre of the track the tie is made in three parts, two end parts and one centre part. The end parts, with the before mentioned addition under the rail, are either constructed as shown in *Fig.* 2 of the drawing with a slight depression immediately under the rail, or as shown in *Fig.* 1 with a gradual batter towards the centre part. Either construction reduces the spreading. The two outer parts of the tie are connected and drawn together by means of a $\frac{3}{8}$ in. by 2 in. steel bar. The ends of this are doubled up and then spot welded to be drilled for the tie drift locking pin without reducing the strength of the bar. At the joints of the centre part of the tie a 3 in. piece of $\frac{3}{8}$ in. by 2 in. steel bar is spot welded on top of the bar, both to strengthen at the joint and to keep the centre block in proper alignment with the outer parts. Both the tie

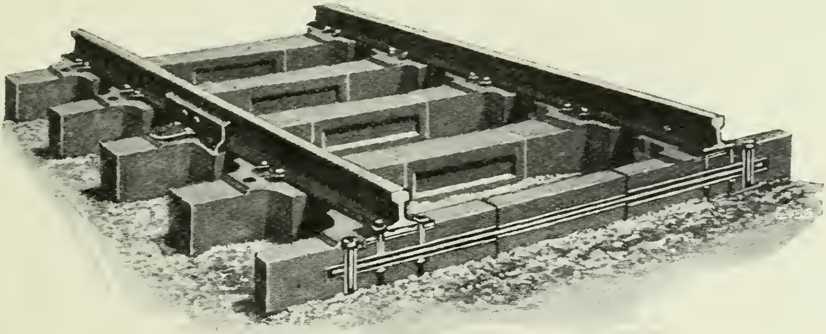


Fig. 1. The Tie installed.

bar and the two tie pins are away from the track bolts or any connection with the rail or the reinforcement, so that the two rails are entirely insulated.

The bearing surface under each rail amounts to 402·5 sq. in., not counting the centre block, which is merely considered a separator between the supporting blocks. The supporting surface of an 8 in. oak tie is 384 square in., figuring the area to the centre of the track.

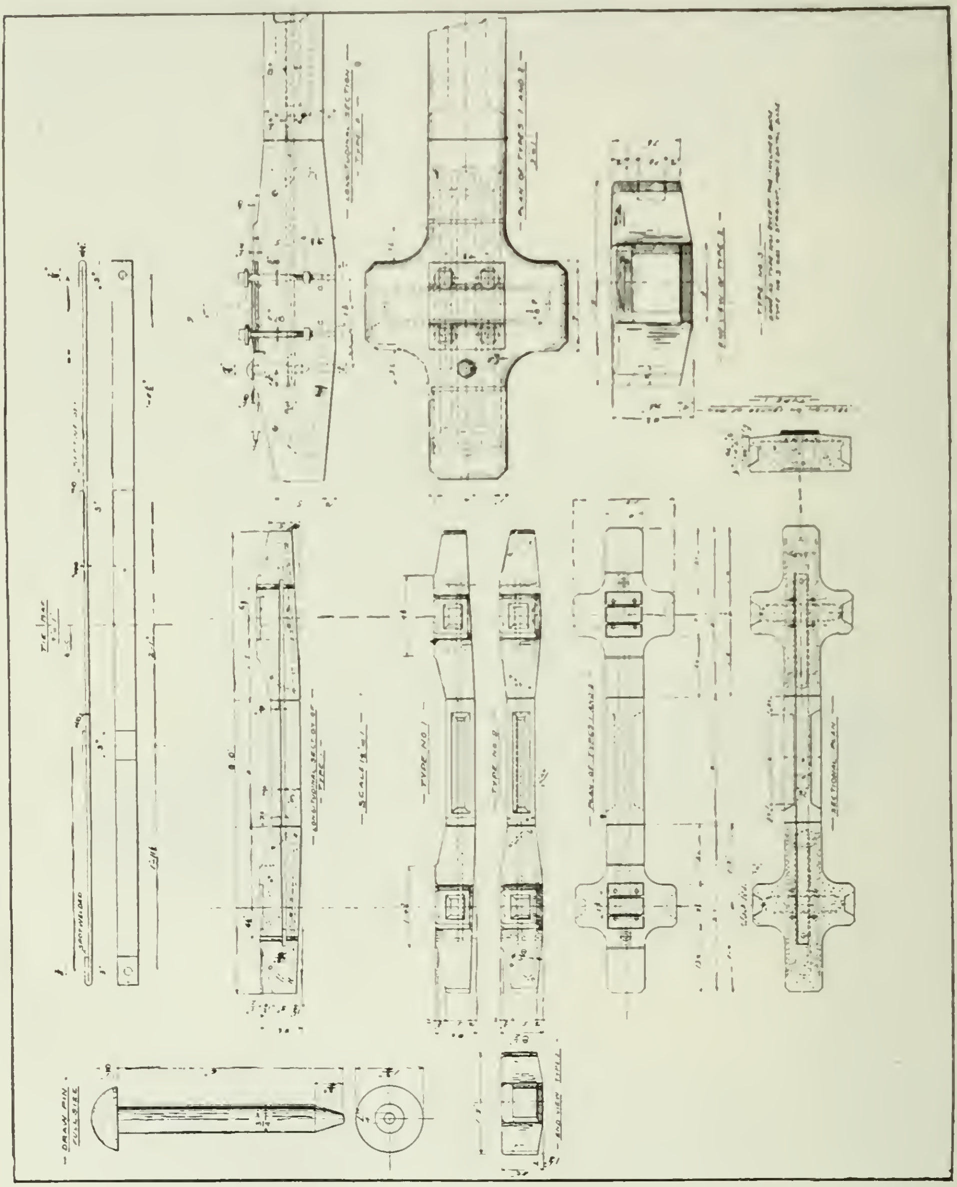


Fig. 2. Details of Tie.

The mixture of the concrete is 1 : 1¼ : 1½ : 3, 2½ or 1 : mixed to a maximum density and the amount of concrete in each tie complete is ·147 cu. yds. The weight of reinforcing steel and tie bar is 44 lb. Thus, when using Haydite at 110 lb. per cu. ft., the tie will weigh 474 lb. complete, and, when using usual concrete ingredients or chats at 144 lb., the tie will weigh 614 lb. complete.

To prevent the jarring results due to placing a steel rail or steel tie plate directly on concrete, a cushion is employed, consisting of a ¼ in. pad of asbestos and mastic packing under the tie plate instead of the wooden pad used by earlier experimenters with concrete ties. A similar pad is also introduced between the end parts and the centre piece, to deaden or ameliorate the effect of impact.

Each tie is provided with four nuts or sockets under each rail and held in the body of the concrete. The location of these nuts is in conformity with the standard spacing of the track-bolts—and can be further secured by connecting the four nuts or sockets by cast steel ribs, but this is by no means a necessity.

The track-bolts have a square head with a circular shoulder plate arranged to fit the slope of the rail flange when screwed down into the sockets, which serves as a lock-nut owing to the leverage given to the friction against the rail flange and thus entirely avoiding the objectionable exposed nut on top. The track-bolts are driven through tight holes in the cushion pad, which effectively protects these bolts from moisture.

Standard fish plates and tie plates are used. Cushion pads and their sockets in the concrete ties are made to fit the tie plates for each standard. In addition to the shoulder of concrete against the tie plate and cushion, the ribs of the tie plates protruding into the seat prevents any tendency of shearing the track-bolts in curves.

In laying the tie bar is shoved through the centre block and the cushion pads forced tightly over the spot-welded caps on the tie bar at the top joints. The end pieces are then shoved into position and the drift locking pins driven in at both ends, the two cushion pads are then squeezed tightly, and the tie in position becomes practically rigid, so the centre block will add somewhat to the supporting capacity of the tie. The cushion pads will also here serve effectively to keep moisture from the tie bar and prevent corrosion. Wood tie tracks may be gradually changed by removing three wood ties and replacing them with two concrete ties.

But fourteen of these ties will be needed for the 30 ft. rail, as compared to twenty of the ordinary wood ties. This will mean a saving of 1,056 ties per mile. If either type 1 or 2 be used, the effect will be to reduce the tension whether a depression occurs directly under the rail or sloping towards the centre block.

MEMORANDUM.

A New Zealand War Memorial.—The city of Auckland, New Zealand, has raised a fund for the erection, at a cost of £170,000, of a Museum and Institute as a memorial to those of its citizens who laid down their lives in the Great War.

The design of the building will be the subject of a competition open to all architects. The Mayor of Auckland has sent a number of copies of the conditions to the Secretary of the Royal Institute of British Architects, and has requested him to take steps to bring the competition to the notice of British architects generally, and in particular to architectural students from New Zealand, who are studying at the British schools of architecture.

Premiums amounting in all to £1,000 will be given to the authors of the first three designs.

The conditions, which have been amended to meet the requirements of the Royal Institute of British Architects, can be seen at the office of the Royal Institute, 9 Conduit Street, W.1. The time for sending in designs has been extended to May, 1922.

CEMENT NOTES.

By Our Special Contributor.

The Education of the Concretor.

During times like the present, when the supplies of materials and labour required for the production of concrete are more than equal to the demand, it is well to consider from a technical standpoint what hindrances there are to the further uses of concrete in this country. Restriction of the survey to its technical aspect eliminates any discussion of cost of concrete, and in effect the question becomes, "How can the technical man foster the uses of concrete?"

All those who have the opportunity of obtaining knowledge of and inspecting concrete work know that complaints arise from time to time that concrete has not hardened satisfactorily or has cracked, and such complaints not only add to the cost of concrete work by the delay they occasion, but are the cause of prejudice forming in the minds of those concerned which tend to retard the development of concrete. In certain cases, the outcome of complaints of the nature referred to is that a particular brand of cement is blamed for the occurrence and debarred from future use, although seldom is this step taken as the result of a reliable investigation as to the real cause of the failure.

From long experience and a careful study of "complaint" investigations, the writer has reached the conclusion that 95 per cent. of concrete failures both temporary (i.e. delayed hardening) and permanent, could have been avoided by the supervisor, whether clerk of works, contractors' foreman, concretor or plasterer, if sufficient knowledge had been possessed of the materials used. Many a complaint could have been prevented if the "man on the job" knew how to test cement for setting properties and how to test sand, gravel and other aggregates for loam and organic matter, and knew when concrete was "killed" and when affected by frost.

The application to the men concerned of the education that is necessary, constitutes a difficulty not easy to overcome. Clerks of works and contractors' foremen are spread all over the country and cannot be reached to any extent by lectures or evening classes, while they are not as a class likely to be influenced by literature.

In the United States, cement manufacturers have taken some steps to solve this problem by appointing field engineers whose duty it is to visit concreting jobs in the district allotted to them and to act as friend and adviser to the contractor on the one hand and as inspector for the spending body or the engineer, on the other hand. Such inspectors are, in the first instance, given opportunities of acquiring an intimate knowledge of their subject, and they are then by tactful advice and warning able to assist contractors with information as to cheap and suitable aggregates, labour-saving methods and so on, while at the same time to fulfil the main purpose of their appointment in taking steps to ensure that the concreting is properly executed and in no way spoilt by wilful neglect or ignorance. It is believed that field engineers are now regarded with friendliness by the vast majority of those they meet in the course of their duties; and they should be effective in raising the standard of quality of concrete in America, which in its turn tends to popularise the material.

In addition to their value as inspectors, these field engineers have an educative influence upon foremen and clerks of works who, as has been mentioned, are difficult to reach in any other way. Advice and instruction are readily received from a practical man such as a field engineer must be, and once a foreman has appreciated what a splendid constructional material concrete can be when correctly proportioned and applied, he seldom loses the knowledge he has gained and becomes an enthusiastic advocate of the use of concrete.

In this way the cement manufacturers of America, admittedly with an eye to business, are performing a service to the community in assisting to produce good work and in educating men who otherwise have to gain their knowledge in a haphazard fashion.

Cement Testing by Independent Experts.

The testing of cement by independent experts is a practice that should be encouraged. Such impartial tests provide for the cement manufacturer a useful check upon the results obtained in his own testing room, and they also serve to maintain the confidence of the engineer and contractor in the material they are using.

The opinion somewhat widely held by cement users a few years ago that the tests obtained by experts bore no relation to practical results and always favoured the manufacturer, is happily disappearing, largely as the result of the standardisation introduced by the British Standard Specification. The fashion of testing for compressive strain concrete blocks made from batches of concrete used in the actual work, is also extending, and this provides the user who is anxious to get what he terms " practical results " with the information required, although it must be emphasised that these tests are dependent not only upon the quality of the cement, but upon the nature of the aggregate and the degree of mixing, to say nothing of such important factors as percentage of water, accuracy of moulding and conditions of storage of the test block. Cement manufacturers when confronted by poor tests of concrete blocks made on the site of the contract are correct in repudiating the results as evidence of the inferior quality of cement, and in maintaining that the cement can only rightly be judged by British Standard Specification tests of the cement itself.

The generally-recognised independent expert cement-testers of this country can be counted upon the fingers of one hand, but it is an unfortunate fact that even with a standard specification to work to, experts are very liable to disagree in their results. One expert can be relied upon to produce the maximum neat tests that a cement will produce, but his sand tests are frequently lower than would be reported by other experts. Another expert seems to have a *penchant* for reporting curtailed initial setting times, while a third is considered to have a tendency to produce high residue tests.

There can be no doubt that in all cases the experts are testing in accordance with the British Standard Specification, and the differences that have been referred to show that there is still need for stricter standardisation. It would be a decided advantage if the experts could meet and agree upon a common interpretation of the specification which could be published or, at least, communicated to cement manufacturers for their guidance.

MEMORANDUM.

Long-Span Concrete Roof Arches for Chicago Garage.—According to the *Engineering News Record* the largest concrete roof arches ever built are believed to be those of a Chicago garage, the arch ribs of which have a span of 103 ft. 7½ in. over the outer faces of the supporting piers. The building is 103 ft. 7½ in. × 161 ft. 4 in. in plan and it was desirable to obtain an unobstructed floor area and ample exterior light at reasonable expense. There are eight concrete arches of the span noted, supported on pilasters in the brick walls; at one end is a 65 ft. arch on concrete columns, in order to allow of an upper floor across this end of the building. All arches have a rise of 17 ft. and are spaced 16 ft. c. to c.

Each main arch is a concrete rib 11½ × 24 in. in section with a short vertical stem at each end seated on a concrete cap on the 17 in. brick pilaster. It is reinforced by three ⅞-in. rods in top and bottom, with stirrups spaced 3 ft. apart, the longitudinal rods being hooked into a spiral at each end of the arch and having their ends hooked at the lap splices. The intrados has nominally a radius of 90 ft., but actually the arch is polygonal, with 10-ft. sides, this arrangement avoiding the expense of curved form work. In the 65 ft. arch the radius is 42 ft. A single 2½ in. tie rod with turnbuckles forms the lower chord. At each end of the tie rod is a nut and bearing plate, the plate at one end taking a bearing against the steel spiral and being embedded in the concrete, while at the other end the plate bears against the outer face of the rib. This rod is 14 ft. above the floor, and to prevent sagging it is supported by five ⅜ in. hooked hangers whose upper ends are fitted with washers and embedded in the arch rib. Turnbuckles provide for adjustment of the hangers.

A rich and rather dry concrete mix of 1 : 1 : 2 was used, with ¾ in. stone as the coarse aggregate. This was partly for strength and partly in view of the cold weather.

SOME ABSTRACTS FROM THE FOREIGN PRESS.

A NEW METHOD OF MAKING CONCRETE.

In order to overcome the possibility of the unequal distribution of the cement in a mass of ordinary concrete, through improper mixing, which may occur, M. Sprenger, a Swiss engineer, has designed a special mixer, termed the aero-malaxeur, in which the moist sand and coarse aggregate are projected through an atmosphere saturated with cement, whereby it is claimed each moist particle is completely covered with the powdered cement, and the mixture produces a concrete of exceptional strength.

The mixer consists of a slightly-inclined cylinder which is rotated on trunnions. Above it is a hopper which is charged with sand and coarse aggregate, supplied by means of a bucket elevator. As these materials fall into the hopper, they are wetted with water, so as to give them the requisite amount of moisture. At the other end of the cylinder is a second hopper containing the cement, which is allowed to pass at a pre-arranged rate into the cylinder, into which it is forced by means of a current of air from a compression, and so meets the grains of sand and aggregate which enter at the other end of the cylinder. In this way, as each particle of sand or stone falls into the cylinder it passes through an atmosphere saturated with cement, and is completely coated with the latter. The mixed cement passes out through the lower end of the cylinder, and is discharged into a wagon or other receptacle.

The mixer is continuous in action, and the one man required has only to see that it is properly supplied, and kept in good running order.

The various parts are so designed as to make the machine almost automatic in action ; thus, if the cylinder rotates more slowly than usual, the elevator delivers a correspondingly smaller quantity of material, and less cement is also supplied.

As the particles of sand and aggregate are completely covered with cement, there is not the same need for the various ingredients of the concrete to be in exact proportion. A small excess of sand does no harm, and the deleterious effect of unsuitable sand is greatly reduced.

The mixer is made in two sizes : the smaller requires 1 h.p., and weighs about a ton ; it has an output of about 5 c. yd. The second has an output of 7–12 c. yd., and requires about 5 h.p. ; it corresponds to the ordinary mixers of ½ c. yd. capacity.

The machine is already in use in several large works, and the fact that it is continuous in action should make it very popular.—*Revue des Materiaux de Construction*, 1921.

OIL FOR CONCRETE MOULDS AND SHUTTERING.

A careful investigation of the properties required in an oil for concrete moulds and centering or shuttering, showed that a good oil should (i) be free from acid ; (ii) be wholly insoluble in water ; (iii) have a viscosity of above 2·3 and below 3·0, at 20° C. on Engler's scale ; (iv) a specific gravity well under 1·00, and (v) a flash point not less than 100° C. ; (vi) the oil should be of mineral origin.

These limits exclude tar oil as well as oils of vegetable or animal origin.

The limits for viscosity are necessary, because if the oil is too thin it flows away, and does not provide a sufficient coating, whilst if it is too thick, it may be difficult to separate the concrete and the mould or centering.—C. R. Platzmann in *Zement*, 1921.

POZZOLANA : ITS USE IN CONCRETE.

Pozzolana is a finely divided material derived from volcanoes, and is sometimes known as volcanic ash. It has undergone various changes since its discharge from the crater, whereby it has been softened, and rendered more easy to combine. The chemical composition of the material is very variable, and whilst in some localities it is a double silicate of aluminium and potassium (leucite), in others it is of so complex a nature as to be almost indefinable, and often contains soluble silica (trass).

Leucite occurs in important quantities in the Eifel district ; in the massive form it is a good building stone.

Trass occurs in large quantities in Italy, and in various parts of the Rhine Provinces, particularly in the Nette and Brohl Valleys.

Pozzolana—from whatever source it may be obtained—is, when ground to powder and immersed in water, feebly hydraulic, and soon sets to a hard mass. The importance of pozzolana does not, however, depend on its primary hydraulicity, but on its power of combining with free lime, to form a strongly hydraulic material of great cementitious power.

In connection with Portland cement (which liberates lime when wetted), pozzolana is a particularly valuable aggregate, as it has the effect of increasing the amount of slow-setting cement present, and preventing the objectionable "wash-outs" which disfigure and weaken so much concrete work.

When mixed with sand and lime in ordinary mortar, pozzolana gives to the latter properties which it would not otherwise possess, and enables it to harden throughout, instead of merely at the surface, as when the hardening is solely due to the absorption of carbon-dioxide from the atmosphere. In other words, the free silica in the trass or pozzolana changes the nature of the reactions which produce hardening, and results in the formation of hard and durable silicates instead of carbonates. By this means the hardening of the mortar is rendered independent of the air, though it is slower than that of ordinary mortar.

When pozzolana is added to cement, in the preparation of concrete, the increase in the time of hardening is too small to be appreciable.

The most suitable procedure is to mix the pozzolana or trass with the dry cement, and to add the mixture to the sand, and to add the water last.

In the case of cement or concrete exposed to sea-water, the use of pozzolana or trass is highly advantageous. Without this addition, the salts in the sea-water and the lime set free in the cement form complex lime compounds, which gradually effect the destruction of the concrete. When pozzolana or trass is present, the lime enters into combination as soon as it is liberated from the cement, and no disintegration of the concrete can occur. The new silicates formed fill the voids in the concrete, and increase the density of the latter.

The proportion of trass or pozzolana to be added should be sufficient to combine with all the lime set free, when the Portland cement is wetted. It is difficult to determine this precisely, but as an excess of trass does no harm, it is generally convenient to use as much trass as cement, and to reduce the sand by the amount of trass added. For instance, a 1 : 2 : 4 mixture would not consist of 1 part of cement, 2 of sand, and 4 of coarse aggregate, but of 1 part of cement, 1 of trass, 1 of sand, and 4 of aggregate. Other customary mixtures are altered in the same manner, the trass taking the place of an equal measure of sand.

It is a mistake to try to replace part of the cement by trass, as the function of the latter is to combine with the free lime from the cement. In practice, however, as the trass does eventually form a new cement, a very slight reduction may be made in the proportion of cement employed, when trass or pozzolana is also used.—*Revue des Materiaux de Construction*, 1921.

WOOD AS REINFORCEMENT.

In localities where iron or steel is difficult to procure, the use of wood appears to be feasible, and Dr. Emperger has made an interesting series of tests, in order to ascertain the value of this material in association with steel stirrups. Prof. J. A. van der Kloes has also made an independent series of tests.

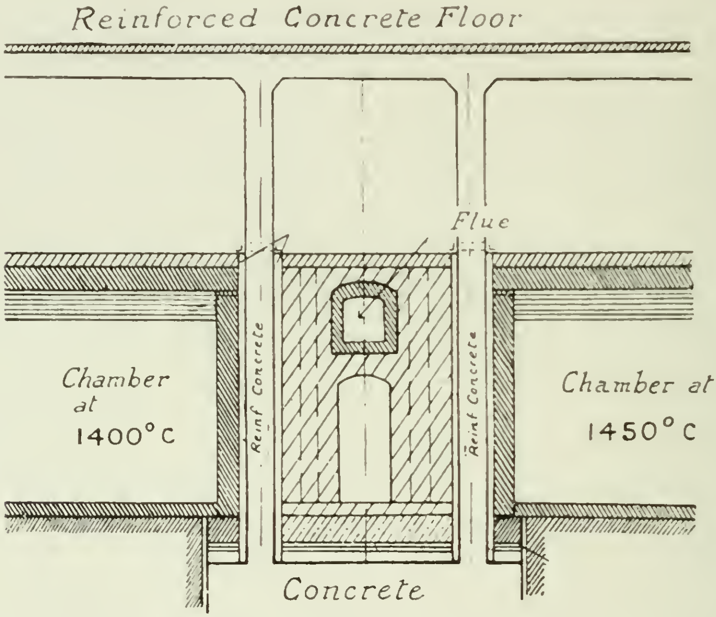
The results of these investigations show that the scope of wood as a reinforcing material is so limited, that it is not worth consideration by builders and engineers, unless a highly penetrative cement, such as Sorce cement, is employed. Wood may, however, be used where the strains are low, so that only a weak reinforcement is required. Hard woods of great durability are preferable to soft timber.—*Le Génie Civil.*

MEMORANDUM.

Crayford Improvement Plans.—The newly-formed urban district council of Crayford, Kent, in order to relieve unemployment, are carrying out road improvement schemes to the extent of £26,000, which, when completed, will very materially improve the district. At the same time they have their own housing scheme under consideration to relieve the overcrowding, and to abolish some of the insanitary areas. In these schemes will be included reinforced roads and concrete bridges.

CONCRETE IN KILN CONSTRUCTION.

In a silica brick works, it was desired to build a floor above a gas-fired continuous chamber kiln, this floor to be reinforced concrete and supported by pillars of the same material. Unfortunately it was necessary for these pillars to be built partly into the kiln, but the brickwork was cut away so as to leave 2 in. clear all around each pillar. It was feared by the owners that the concrete would be overheated and destroyed by the heat from the kiln as the contents of the latter were strongly heated to 1,450° C. and maintained at that temperature for a considerable time. After a year's use, the pillars do not show the slightest signs of damage or of shrinkage, and it appears that concrete is well able to stand the exceptionally severe conditions just described. . . .—*Tonindustrie Zeitung*, 1921.



MEMORANDUM.

British Standard Channels and Beams.—It will be recalled that in August, 1920, the British Engineering Standards Association issued a new list of British standard rolled steel sections for structural purposes. This list contained particulars of the dimensions of the sections with their areas and weights, but no details of the geometrical properties such as the moments of inertia.

The Association has now issued these latter for the beams and channels, and they should prove of value to users and manufacturers, supplying as they do authoritative figures, which would otherwise have to be calculated independently. In addition to giving the dimensions and properties in British units, tables have been added showing the metric equivalents of these for the convenience of users in countries in which the metric system has been adopted. It is, however, indicated that the figures in inches or pounds are to be regarded as the standards.

In this new list, the symbol "*J*" has been adopted for the moment of inertia, and the term "modulus of section" has been substituted for "moment of resistance," the symbol "*Z*" being adopted in place of "*R*" which was formerly used.

The new publication (Report No. 4, 1921) can be obtained from the Offices of the British Engineering Standards Association, 28 Victoria Street, S.W.1, or from Messrs. Crosby Lockwood & Son, 7 Stationer's Hall Court, E.C. Price 1*s.* 2*d.*, post free.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Reinforced Concrete Construction." By M. T. Cantell, Licentiate R.I.B.A., Associate Surveyors' Institution.
Part II. Price 16*s*. net. E. & F. N. Spon, Ltd.

The author states in the preface that numerous fully worked out examples are given including the necessary information for design of types of structures for which reinforced concrete is at present generally employed, and that, in the majority of cases, the examples are accompanied by explanatory diagrams and working drawings and illustrations of recently concluded work similar to that dealt with in the examples.

We can only conclude that he has a very imperfect idea as to what constitutes a proper design and a working drawing; since, in our opinion, there is nothing in the book which approximates to our idea of the requirements of either, and without having the advantage of knowing how much experience Mr. Cantell has had with the practical design and construction of reinforced concrete, we get the impression that his energies have mostly been diverted to other subjects. *Fig.* 90 and *Fig.* 38 showing arrangement of reinforcement, show the very worst possible arrangement which could be devised—the square rods being arranged in two layers practically touching at the corners, so that it would be a physical impossibility to get any concrete under them, and even if they were grouted up with liquid cement the casing would be bound to fall off.

The article on Arches contains some statements which civil engineers will find diverting. The whole of this article is well worth reading, but space prevents reproduction of more than a few lines:

"The chief advantage of reinforced concrete arches are their resistance to tension; lightness with rigidity and strength; slight expansion or contraction under variations of temperature."

"*Temperature stresses.* As in all concrete work, the variations of temperature will cause expansion and contraction of the arch, which will develop cracks if the reinforcement is not properly distributed. As arches usually contain a large proportion of concrete to reinforcement there is generally sufficient concrete to meet the shear stresses without special members; but the steel is insufficient and is not distributed in the best manner to resist the expansion and contraction; consequently it is advisable to employ shear members for this purpose, whether required or not for the shear stress."

The net result of the author's deliberation on the subject of temperature stresses appears to be as follows:

"Provision for the extra compression or tension would be hardly necessary. However, if desirable, it will be sufficient for the purpose if the arches are designed in the usual way, but with a larger factor of safety, say 500 lb. per sq. in. for the concrete and 15,000 lb. per sq. in. for the steel."

We gather that it has not occurred to the author that the effect of temperature variations in arches is to cause the crown to rise and fall and to set up bending stresses which may be considerable. What the first paragraph quoted above on the subject of temperature stresses is intended to mean we must confess we have not the faintest idea, and frankly we think it is a pity that books should be written on technical subjects by authors whose acquaintance with the subject seems in places to be of the slenderest. One of the most hopeful remarks we found in the preface:

"The author has found it to be quite common for students and others to doubt the strength of their designed structure."

As regards the large number of illustrations, the great majority of these were at once recognised as old friends from the various catalogues of the specialist designing firms, and from the pages of well-known technical journals. The reproductions of these illustrations are mostly unusually bad, *Fig.* 237 being perhaps the worst; in any case it appears to us to illustrate nothing whatever and why it was included we cannot understand.

O. F.

"Concrete Designers' Manual." By G. A. Hool and C. S. Whitney.

McGraw-Hill Publishing Co., Ltd., 6 Bouverie Street, E.C.4. Price 24s. net.

This book is a compilation of tables and diagrams for the design of reinforced concrete structures, and contains practically no subject matter apart from the tables and diagrams and the appendix which gives the American Joint Committee Recommendations, the American Concrete Institute Recommendations, the New York Building Code Requirements and the Chicago Building Code Requirements—all, of course, on the subject of reinforced concrete. It is, therefore, not a book which is suitable for students, but is only intended to be a labour-saving device for designers continually engaged in figuring reinforced concrete projects in accordance with the regulations already mentioned.

The diagrams are extremely clear and well designed and give, for example, the safe load on solid concrete slabs for different spans and thicknesses and stresses with various bending moments such as $\frac{WL}{8}$ $\frac{WL}{10}$ $\frac{WL}{12}$. Apparently it is not usual in America to cater for other moments, and it is remarkable that a country so very bold in its flat slab construction (otherwise called mushroom) should be so extremely conservative in regard to its design of ordinary slabs.

Tables and curves are then given for ribbed slabs or slabs lightened with hollow tiles, and the author then gives tables for flat slab construction for each of the following regulations :—The American Concrete Institute, New York City, and Chicago. He states that he has omitted to give the tables for the Joint Committee recommendations, as they are so conservative that they are not used to any extent.

Tables are then given for ordinary rectangular beams which we should have expected to find much earlier in the book, doubly reinforced beams, T beams, and shear reinforcement.

These are followed by tables for columns, separate tables for the recommendations of the Joint Committee, the American Concrete Institute, the Chicago Building Code, and the Los Angeles Building Code, both for round and square columns, for various concrete mixtures and stresses, and this portion of the work occupies by far the largest portion of the book ; the tables on columns occupying altogether from page 91 to 198, excluding the sections on bending and direct stress, which after all are most frequently used in connection with column design and which occupy a further 34 pages.

Tables are then given for footings with different soil pressures. These are followed by miscellaneous weights and by the appendix of the various recommendations already enumerated.

The book is excellently got up and probably achieves what it set out to do as well as is possible.

As long as the purchaser realises that he is not buying a book from which he will learn anything about the theory of reinforced concrete, but is buying a labour-saving device for reducing the amount of arithmetic necessary, we would strongly recommend the work. For English readers it is of course a disadvantage that it caters entirely for American regulations. Whether a competent designer really, in the long run, saves time by looking for what he wants in a book of tables of 250 pages instead of working it out direct on a slide rule from such simple formulæ as can easily be carried in the head is, of course, another question altogether on which we, personally, hold the view that the latter method is often the quicker and gives in time a very great facility and an increased confidence, owing to the feeling that one is not helpless when separated from the book of reference on which one has become accustomed to rely. Subject to these general remarks, we strongly recommend the present work as having admirably accomplished what it set out to do.

O. F.

Government Cement Plant for Ontario.—It is reported that the Ontario Government has decided to erect a cement manufacturing plant, at a cost of about £200,000. The cement will be used mainly for the manufacture of concrete for the construction of roads.

QUESTIONS AND ANSWERS RELATING TO CONCRETE.

In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—Ed.

Question.—*K. L. W. writes:—Suppose you are to design a reinforced concrete floor for a bridge to carry, say, a Rochester Roller; this floor is to consist of main beams spaced equally and a slab on top* with no cross beams.

1. *What would be the effective width of slab which will resist the concentrated wheel loads? Please cite me some references, preferably original papers and not text-books.*

2. *Are the side and central slabs (say there are 6 beams with 5 bays) to be all considered as simply supported or as continuous, or is there any differentiation between them? Would the expression for the B.M. for uniformly distributed loads be* $\frac{wl^2}{8}$, $\frac{wl^2}{10}$ or $\frac{w^2}{12}$?

Answer.—1. Provided the slab has cross reinforcement equal to the main reinforcement, then it is satisfactory to allow a width of slab equal to the span as carrying the load.

If the cross reinforcement is much less, take a width of half the span.

2. The end slabs are continuous one end, and the three central slabs both ends.

It is safe to design the end ones for $\frac{wl^2}{10}$ and the central ones for $\frac{wl^2}{12}$ when the loads are uniformly distributed, and sometimes smaller moments are safe, depending on the ratio of live load to dead load and the stiffness of the supports.

Question.—*W. H. S. writes:—I shall feel obliged with expert advice through the Correspondence Columns regarding diagrams for the calculating of reinforced concrete. It will be beneficial to me personally, and probably to other readers to know of a set of diagrams now on the market which give accurate results and comply with the requirements of the L.C.C. Regulations and other recognised standards.*

A brief general discussion comparing this method with that of calculating by formulæ, would also be of interest. Thanking you in anticipation.

Answer.—The inquirer does not state what diagrams he refers to. Practically all books on Reinforced Concrete give diagrams.

Thus, Faber & Bowie's *Reinforced Concrete Design*, Vols. I and II, give diagrams of the depth of neutral axis for various percentages of steel and stresses, resistance moments for various percentages, bending moment diagrams for many ratios of dead load to live load, with different systems of loading and end fixity, moments in pillars for different ratios of beam and pillar stiffnesses, etc. These comply with L.C.C. requirements.

Reviews of many other books have appeared in these pages recently from month to month (*q.v.*) many of which are full of diagrams and the reviews often draw attention to the fact.

The objections to relying too much on diagrams are:

1. A tendency to forget the basis on which the diagrams are based and then to use them outside the conditions to which they apply.

2. They tend to produce a lack of elasticity in design.

3. A young designer fails to learn the real basis of design, and therefore,

4. Progress in the search for truth is hindered.

CORRESPONDENCE.

Under this heading we invite correspondence.

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

DEAR SIR,—The article on "Output in Building Work" in your September issue states that "America can compete with this country in the markets of the world despite the fact that the workmen are paid over twice as much wages." The context makes it clear that skilled labour only is referred to, and it may interest your readers to know that the same relation in regard to American and British rates of pay does not apply to unskilled labour.

In May of this year, unskilled labourers were being engaged for cement works in the Lehigh Valley—the home of the American cement industry—at 25 cents per hour, equivalent to 1*s.* 0½*d.* at normal exchange, and, say, 1*s.* 4*d.* at current rates of exchange. During the same month there were very few cement labourers in England receiving less than 1*s.* 5*d.* per hour.

Others may argue from this that British rates of pay are too high, but I will content myself with pointing out that in the cement industry, and probably many other industries, the British manufacturer no longer has the advantage he formerly enjoyed over his American competitor of paying lower wages, and he is consequently in the position of paying higher wages for less output per man.—Yours faithfully,

P.

To the Editor, CONCRETE AND COSNTRUCTIONAL ENGINEERING.

Re Fire Resistance of Reinforced Concrete Work.

DEAR SIR,—We are very strongly of opinion that the well-known fire-resisting qualities of reinforced concrete work are not sufficiently brought to the notice of the public.

As you know, one of the largest and best known stores in Paris has just been entirely burnt down owing to the fact that the whole of the building was constructed in steelwork. We venture to say that if this important building had been constructed in reinforced concrete it would have been possible to localise the fire and to save, if not the whole structure, at least a very large portion of it. The loss in this case is estimated at about a million pounds.

In spite of the repeated disasters due to fire which are occurring every day in all parts of the world owing to the use of unprotected steelwork, this method of construction is still being used to a larger extent than reinforced concrete work, at least, in our country. Architects and their clients appear to think that as long as the building is safeguarded by an ample insurance and by some system or other of sprinklers the matter is at an end as far as they are concerned, and the Insurance Companies apparently encourage this way of thinking, as in our opinion they do not encourage sufficiently reinforced concrete by reducing considerably the premiums in the latter case as compared to the premiums which they are asking for steel construction.

In the case of a large shop premises like the Magasin du Printemps, the loss of trade during the period of reconstruction will no doubt be very considerable indeed, as this was probably not insured.

Many years ago our Company went to a very considerable expense in having large reinforced concrete floors constructed and tested to destruction by the British Fire Prevention Committee, in order to prove in a positive manner that properly designed reinforced concrete was the most fire-resisting material obtainable. The excellent results obtained at these tests are well known and many other specialists in reinforced concrete have also tested their floors to the effects of fire with equally good results.

We regret to say, however, that our experience has been that architects and their clients do not evince any interest either in these conclusive tests or in the obvious fact that reinforced concrete construction is more resisting to the effects of fire than steel construction. Yours faithfully,

For and on behalf of
EDMOND COIGNET LIMITED,
G. C. WORKMAN,
Managing Director.

Concrete Roads and their Construction.

Extracts from an article received from J. H. Walker, Assoc.M.Inst.C.E., on the subject of Concrete Roads, which space does not admit of our publishing in full.

Any observant engineer experienced in concrete constructional work may be pardoned if he views with great uneasiness some of the methods of road construction now in use. Many consider that in concrete roads, scientifically designed and carefully constructed, lies the successful solution of economical smooth-surface roads, easy of maintenance and free from corrugations and undulations, which roads will be capable of carrying much heavier and faster traffic than that of the present day. If, however, through want of care and a proper understanding of the difficulties to be surmounted, it should happen that failures occur in any of such roads now being constructed, it may perchance that concrete roads as such may quite wrongly get a bad name, and the era of good and economical roadways be delayed indefinitely.

* * * * *

Previous to the execution of work of any magnitude it is essential to have a clear conception of the characteristics of the material used, both as delivered on the job and when built in the work. . . .

CHARACTERISTICS OF CONCRETE.

The following are a few facts (partly taken from *Concrete, Plain and Reinforced*, by Taylor & Thompson), relating to concrete, which it is essential should be borne in mind when constructing concrete roads :—

Concrete in setting contracts $\frac{5}{8}$ in. or more in every 100 ft. and, in addition, contracts $\frac{1}{3}$ in. in 100 ft. for every 50° F. drop in temperature. Consequently, concrete laid in place in air at a summer temperature of 75° F. will have a total contraction of about 1 in. in every 100 ft. when, in winter time, the temperature falls to 25° F.

The tensile strength of concrete is so low that a small change of temperature will crack it. A fall of 1° F. puts a contraction stress on a long concrete slab of 11 lb. per square inch, i.e. a fall of 27° F. is sufficient to crack concrete with a tensile strength of 300 lb. per square inch. Conversely a rise of temperature of 50° F. subjects it to a compression stress of 50×11 lb. per square inch $= 550$ lb. per square inch.

It is evident from the above, and it has been proved by experience, that there is less cracking in concrete laid in cold than in warm weather. It would be advantageous, therefore, in this respect to lay concrete roads in winter.

* * * * *

Professor A. H. White has shown that concrete, even when twenty years old, expands when wetted and shrinks if dried, and that with rich mortars these variations cause changes much greater than those due to temperature. . . . A small bar cut out from a side-walk after twenty years' service elongated 0·175 per cent. (i.e., equal to 2 in. in 100 ft.) by successive immersions at room temperature.

It naturally follows from this that with concrete in exposed positions, when the movements in any direction are restricted, every means possible should be taken to avoid alternations of extreme wetness and dryness. This of itself should form a good argument for coating the surface of a concrete road with tar or bitumen.

When concrete of the usual working consistency is laid and punned in position, a laitance scum always works to the surface. This cement milk, laitance scum or whatever name best describes it, is made up of inert or drowned cement with little or no strength. When dry it rubs up with the finger into a powder and practically acts like a coating of French chalk or anti-fouling paint in preventing a proper bond between abutting or superimposed layers of concrete.

JOINTS.

. . . In the case of a long concrete road slab contracting under setting or temperature influence, the weakest places are the day-work joints, and at such places the road will inevitably crack.

A stoppage of only a few hours will cause a weak place in a day's stretch of concrete road, and later be responsible for a crack appearing at that place. In two-course roads where the top wearing surface is placed in position on the bottom layer after the latter has set, the laitance, unless washed off whilst the bottom layer is green or picked off when the bottom layer has set hard, will cause imperfect bond. This, in summer when the road expands due to heat, with the top layer being most affected, results in the top layer sometimes buckling upwards and parting company with the bottom layer. If this happens the fast, heavy traffic soon plays havoc with a concrete road surface, particularly at the day-work joints.

* * * * *

CURING THE SURFACE.

An ordinary dressing of tar and chippings, laid on a concrete surface well washed and brushed, whilst the concrete is green, so as to leave the large granite aggregate standing up clear and free from dust and laitance powder, should stick perfectly and wear like an asphalte road without the countless small cracks so common in an unstable tar-sprayed coating laid on a dusty macadam base, and consequently subject to continual local bending, day and night, wet or fine. . . .

A trial length of such a concrete road surface, properly washed, brushed and tar-sprayed, etc., in the spring of 1920, i.e. eighteen months ago, is still in perfect condition, whilst the exactly similar dressing put the same day on the macadam road adjoining, wore off before the winter, and had to be renewed this summer. . . .

REINFORCEMENT.

Reinforcement in concrete, when the latter is placed in position continuously, i.e. without stoppages at night-time or week ends, will not prevent concrete from cracking, but the cracks will be smaller and spaced at shorter distances according to the increase in the amount of reinforcement. . . .

In concrete slabs of large area, reinforcement is required :—

(*a*) To prevent cracking due to setting contraction.

(*b*) To prevent cracking due to temperature changes.

(*c*) To strengthen the concrete due to flexure and contra-flexure stresses put upon it by heavy rolling loads.

For (*a*) a suitable amount is say 0·4 per cent. = 2 lb. per square foot of sectional area, i.e. in a road 9 in. thick an amount of 4½ lb. in a transverse and also a longitudinal direction, i.e. 9 lb. per square yard.

As regards (*b*) the stresses due to a fall in temperature are additional to those allowed for in (*a*), and further steel is required.

As regards (*c*) the above amounts of steel work being fully employed on a cold winter's day in providing for stresses involved by (*a*) and (*b*), extra steelwork is required for flexure and contra-flexure stresses, which amount of steel depends upon the maximum rolling axle load and the bearing capacity of the soil. The total result is that for heavily worked dock roads on indifferent formation, a reinforcement of 12 to 17 lb. per square yard is required. For country roads on good formation a less amount of steel can be used, but it is desirable now that steel is so considerably reduced in price not to spoil the ship for a pennyworth of tar.

To reinforce a concrete slab efficiently to meet the requirements of case (*a*), the steel should be uniformly distributed over the cross-sectional area, i.e. it should either be inserted in a single layer in the centre of the slab or, alternatively, have a top and bottom layer each interlocked with diagonal members connecting the two layers together.

Again, as regards case (*b*), we have diurnal and seasonal changes of temperature to consider which call for a similar arrangement of steel as in case (*a*). In this case (*b*), the top surface is the one which is subjected to the greatest extremes of temperature, such as the range between a very hot summer's day and a particularly cold winter's night. To meet these extreme variations, more reinforcement is required near the top surface of the slab than the under surface. . . .

In case (*c*), where we have heavy rolling loads to contend with, it is obvious that at the point of contact with the surface the slab tends to sag downwards in a saucer-like depression, with a resultant tension on the under side of the slab, whilst on the rim of this assumed saucer-like depression there is a contra-flexure with tension at the top of the slab. As the load is a rolling one, this action calls for reinforcement both longitudinally and transversely at the top and bottom as in cases (*a*) and (*b*), and further, as concrete is particularly weak in shear, diagonal reinforcement is again indispensable to connect the top and bottom layers of steel together, and so make a girder-like mattress to supply the diagonal tension strength as requisite in a slab foundation as in any other well-designed concrete structure.

* * * * *

It would be considered the height of bad design to omit shear reinforcement in the girder or floor slab of a building, and it is just as wrong to omit it in a raft or concrete road.

How to avoid Cracks.

As stated previously, cracks must inevitably occur at day-work joints. . . . Any extra steel at a day-work joint will not prevent these cracks, as the crack is started whilst the cement is still green with little or no bonding strength on to the steel reinforcement. Where there is a crack, water and air can in time percolate and rust away the steel along the crack. To rust this part of the steel away completely will take some time, but it is a mere percentage of the time a well-constructed and maintained road of concrete should be expected to last.

This raises the question as to the advisability of carrying the steelwork through a day-work joint, and the answer is certainly in the negative. If the steelwork be not made continuous over day-work joints, the making of vertical stunt ends is at once simplified, and the road can be finished each evening with a vertical face. . . instead of the pernicious practice of keeping the end of the wearing surface some inches back from the edge of the lower concrete. A method has been evolved and put into everyday practice, whereby the well tried, old-fashioned and excellent practice in first-class work, of laying the concrete firstly in alternate bays, and after they have set hard and partly taken up their setting contraction filling in the intervening bays is followed, in combination with a simple and inexpensive system of interlocking all the adjacent bays together in transverse and upward and downward directions. This method is shown in the diagram on page 753.

It is interesting here to note that Mr. Boulnois in 1917 published a draft specification for the making of concrete roads in which he recommended the concrete to be laid in alternate bays. It is necessary, however, to point out that such bays with ordinary vertical joints are, without a system of interlocking one with the other, open to a great objection of tending under heavy loads concentrated on the edges to sink locally like a raft at sea similarly loaded, with the result that the wheels pound and wear away the raised arris of the adjacent slab. . . .

Expansion of Concrete through Heat.

Concrete expands through heat $\frac{3}{8}$ in. per 100 ft. for every 50° F. rise of temperature. In a long stretch of concrete road subject to exceptionally high temperature on a blazing hot summer's day, concrete even with expansion joints has been known to fail by buckling upwards, partly perhaps due to too little thickness and consequent lack of weight to keep it down, and also to bad workmanship at the day-work joints where each stunt end has been left at night with a laitance-covered slope instead of a perfectly vertical face from the formation to wearing surface. In the latter case failures have taken place through the slab at one side of a joint sliding upwards over the adjacent slab (see Concrete and Constructional Engineering for August, 1921). It is advisable, therefore, to have a sufficiently thick slab and not to err in the other direction from a false economy point of view. . . .

Thickness of Concrete Surface.

The present American practice is towards giving increased thickness over those previously employed. Requirements from roads in Great Britain are more exacting than in American country roads fed by rutted grass tracks unsuited for heavy British road traffic, and where in the United States cracks in the roadway are looked upon by many engineers as inevitable and accepted as such. It is therefore not to be accepted as indisputable that English practice should follow blindly on American practice, either as regards thickness of slab, method of construction or the complacent acceptance of irregular cracks in the road surface, which latter in Connecticut and other places have obviously been found to be far more difficult of maintenance than straight thin joints of predetermined spacing.

Suggestions for making a Concrete Road.

It is, however, an easy matter to criticise. . . . Far more instructive it is to state how concrete roads should be made. . . . This we will now describe, and for our purpose take . . . a stretch of concrete road 30 ft. wide. The concrete is of a minimum thickness of 9 in., 10 in. or 11 in., according to the nature of the formation, etc. The bottom layer of concrete is of 6 to 1 ballast concrete, whilst the top layer, 2½ in. thick, consists of a 1 : 1¼ : 3 mix, the aggregate being of tough granite well broken into approximate cubes to pass through a 2½ in. ring and be retained on a 1½ in. ring, all flakey granite to be rejected. The reinforcement to be of double-layer mesh connected together with diagonal tension members. The weight of the mesh to be 10 lb. per square yard and upwards, according to requirements. The top layer of concrete to be laid on the bottom layer before the latter has set. As soon as the top surface can be walked upon without injury, it must be well washed and broomed to remove the laitance and so leave each granite stone clean and standing well out of the mortar. The concrete to be kept wet for ten days after setting. Some time before traffic is put on the road the surface to be well brushed clear of dust and grit and to be covered with tar or bitumen and granite chippings. . . . This carpet is easily renewable every one, two or more years, according to amount of traffic, and in addition to taking the wear serves also to protect the concrete from varying alternations of wet and dry with its consequent bad effects. . . . A bitumen or tar-dressed road gives a water-proof coating to the concrete, and prevents alternations therein of extreme wetness and dryness, with their accompanying detrimental effects. Properly applied, it has a far longer life than on a macadam road—it is easier to renew it than to hack out and patch up holes and depressions in the concrete—it is not glaring to the eyes like an uncoated concrete road, and it is more pleasant for the traffic to pass over. Concrete roads, although a new departure in engineering, are entitled to just as much fair play as steel bridges and exposed timber structures, which are painted and repainted as and when necessary.

The concrete to be laid in alternate bays 10 to 12 ft. wide with the reinforcement not continuous from bay to bay, and the bays are preferably placed at an angle of 1 in 3 or up to 1 in 1 instead of square across the road. The intervening bays to be filled in after the alternating bays have set hard and have taken up part of their setting contraction. This results in the inevitable 1 in. contraction in each stretch of road laid continuously in day-work length of 100 ft. being split up into straight joints about $\frac{1}{15}$ in. wide instead of the large straggling cracks so detrimental to maintenance. The tar or bitumen coating afterwards applied has sufficient plasticity to span these thin joints. These latter act as expansion joints to provide for increases in temperature even in cases when the road is laid, as is preferable, in the colder months of the year, when the resulting crack in the joint will be less than in roads laid in hot weather.

The reason for the inclination of the slab out of the square with the road is . . . that as each slab is practically a raft on a more or less movable foundation it is desirable . . . not to have both the wheels of a heavy axle load resting on the edge of a slab at one time but rather to have the weight spread on two slabs. The same reasoning accounts for the adoption of the simple form of concrete vertical forms with the slip-in pieces whereby each adjacent slab is interlocked vertically and sideways, one with the other, in such a manner that the weight of a rolling load passing over a joint is at all times supported by both slabs. . . .

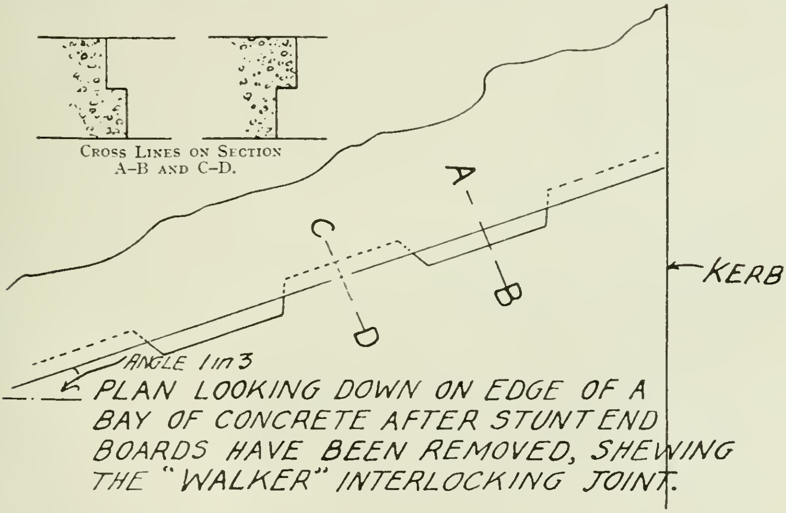
It will be readily seen that with the alternate bay method of laying concrete areas . . . it is necessary to carefully plan . . . carrying out the work at site in order to obtain maximum efficiency and economy in the road itself together with a minimum of time required to execute the work.

* * * * *

PLANT.

The first considerations are the forming of the road bed and the delivery of materials to site. These will vary according to circumstances. . . . A suitable arrangement is to store the material beforehand at various depôts along the road, spaced at say suitable intervals of 400 to 600 ft. The concrete material is . . . dumped in mounds on the formation at suitable temporary depôts. The concrete mixer can be oil-driven and of ¾ cub. yd. capacity with an elevating hopper.

The road is spanned by a small type " Walker " overhead strut cableway crane, with a travelling portal trestle on one side of the road, and on the other side of the road a trestle mounted on a travelling platform on which latter is the operator with two winch drums and oil engine for actuating the cableway. The rails on which the trestles run need only be of light section spiked to longitudinal planks so as to be easily taken up, transported and re-laid. A light lattice girder with an attached cableway underneath is supported by block and tackle from the tops of the two trestles. This girder is of light construction, needing only to be made sufficiently strong as a beam to carry its own weight, and can be lengthened for use on a 40 or 50 ft. wide road by inserting the necessary extra length at central bolted field joints. As the girder is flexibly supported from the trestles, it is of little importance if the girder is level or inclined, or whether one trestle be moved somewhat ahead or behind the other trestle.



PLAN LOOKING DOWN ON EDGE OF A BAY OF CONCRETE AFTER STUNT END BOARDS HAVE BEEN REMOVED, SHEWING THE "WALKER" INTERLOCKING JOINT.

This cheap and quick-working crane, which may be motor-driven or hand traversed, can be converted into a tent by placing two scaffold poles across the road, supported by the under-framework of the two trestles. The suspended girder acts as a ridge over which to throw an awning, the two bottom edges of which are attached each to the foot of one of the scaffold poles. Such a tent can be internally lighted when the crane is in use on a dark winter's afternoon or otherwise.

* * * * *

. . . The concrete is conveyed from the mixer on a small rail motor-driven waggon, running on a narrow-gauge track. This car has a platform large enough for the two concrete tipping skips. The car takes a full skip from the mixer and runs with it under the portal trestle and stops under the cable way. The empty skip from the cableway is deposited on the car and the full one removed. The car then runs back to the mixer to get the empty skip refilled. The reinforcement proposed is of the double layer pyramidal mesh rendered familiar by the Walker-Weston Co., Ltd., and is bent and assembled in full-bay sections on the lightly constructed movable assembling platform shown. The steel used is as sent direct from the rolling mills, all necessary bending being done at site.

* * * * *

. . . The motive power has been assumed above as of the internal combustion type, but a dynamo driven by an oil engine, both mounted on a bogie and supplying current to an overhead wire from which each machine and the lighting installation takes its current, is well worthy of great consideration, as also are other sources of power perhaps specially suited to the requirements of a particular locality.

It will be readily seen that all the plant is easily movable, with the assistance of the small power-driver small gauge motor car, and little delay results when it is necessary to move along the road to another depôt.

Advantages of Laying in Alternative Bays.

To one who has carefully followed the above description some additional advantages of the alternate bay method interlocked as described must at once be apparent, viz. :—

(*a*) Speed, economy and comfort in construction.

(*b*) The provision of one or two planks spanning the narrow width of the bay enables the men to place the concrete in position without having to walk in about the concrete and reinforcement.

(*c*) Each alternate bay is allowed time to set hard and take up part of its setting contraction, with the advantage that the arrises are not likely to be damaged in putting in the intervening bays, as is the case when the stunt end boards are kept in place only from night till morning in roads laid in long lengths laid continuously.

(*d*) The screeding and the washing off of the laitance is facilitated, also the men need not walk on the newly set concrete to do the latter.

(*e*) The work can be carried out in winter, as it is easy to provide and put in place over the wet concrete in the narrow bays mats for protection against possible night frosts. . . . Further, concrete laid in winter is less likely to crack than when laid in summer, and also does not require constant wetting and keeping moist whilst maturing.

(*f*) Laying of concrete roads on gradients is facilitated, on account of the bays being only 10 ft. wide in the direction of the length of the road and the gradient.

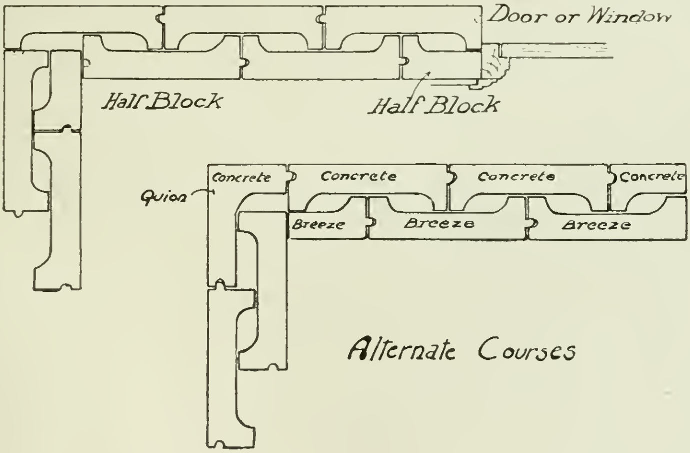
(*g*) By using an awning suspended from the overhead boom of the crane and so covering over the bay being concreted, together with the use of oilskins by the four or five labourers at the mixer, concreting can proceed in wet weather and thus avoid the otherwise certainty of unauthorised cracks where the work has been stopped for a short time. The provision of one or two electric lights attached to the boom will give ample illumination on a dark winter's afternoon.

. . . . It is considered that enough has here been said to make road engineers carefully consider the advantages of the interlocked alternate bay system of constructing concrete roads when compared with other " get on with it and chance it " methods. The writer at one time adopted continuous methods, notwithstanding the fact that he was acquainted with the ordinary alternate bay method, and the advice of such an experienced engineer as Mr. Boulnois. It was only through experience of the evils inherent in the one system and a determination to overcome them in the construction of heavily worked dock roads, that it became obvious the theoretical and practical solution of the problem of making successful concrete roads lay in the adoption of the alternate bay method when the latter was rationalised by the method of interlocking above mentioned.

NEW METHODS OF CONSTRUCTION.

FACTORY-MADE CONCRETE BLOCKS.

A branch of the concrete industry that has not been developed in this country to the same extent as in some other countries, particularly the United States, is the manufacture of concrete units in the factory. By this system all the parts required for the construction of a building on the concrete block system, such as blocks, slabs, sills, lintels, copings, etc., are made in a factory and delivered to order in exactly the same way as bricks are ordered from a brickyard, with the added advantage that where, as in the latter case, the bricks have to be obtained from one firm and the stonework from another, in the former case the whole of the constructional work usually carried out in brick and stone can be obtained in concrete at the same time from the same factory. It is claimed that the mass production methods, rendered possible by this system, result in the manufacture of the units at a very cheap rate, and, from districts where a supply of suitable aggregate is not readily available, factory-made blocks provide a convenient means of building in concrete. Transport charges, of course, have to be taken into account, but concrete blocks can be delivered at a lower price than the number of bricks necessary to build an equivalent area of brickwork of the same thickness, and, further, the cost of erection of the concrete units is considerably less than the cost of erection of brickwork.



The " Utility " concrete block illustrated is manufactured on these lines by Messrs. J. Wright & Co., of South-Western Works, New Malden, Surrey. The blocks measure 18 in. by 9 in. on the face and are $5\frac{1}{2}$ in. across the widest part, the bead and hollow at the ends forming a very secure joint. A complete cavity is formed throughout the wall. For thicker walls the blocks are laid three deep, or for a solid wall, the blocks can be used as the inner and outer face at any distance apart and the cavity filled in with concrete. The blocks are made in ballast concrete for the exterior wall and breeze concrete for the interior wall, thus preventing condensation, and, as the breeze blocks are made with a true face, plastering is not necessary. The blocks are of a size that enables them to be easily handled, and with the use of half-blocks practically any design can be carried out. The firm also supplies partition blocks, fixing blocks, etc.

MEMORANDA.

*Memoranda and News Items are presented under this heading with occasional editorial comment. Authentic news will be welcome.—*Ed.

The Concrete Utilities Bureau.—On the 6th October, Mr. E. Fiander Etchells, President of the Concrete Institute, paid a visit to the Permanent Exhibition of Concrete Products installed at 143 Grosvenor Road, S.W.1, by the Concrete Utilities Bureau of 35 Great St. Helens, E.C.3.

Among the exhibits inspected by Mr. Etchells were a telegraph pole, a septic tank, a drinking trough which had been kept filled with water for over three years, concrete piles, sewer pipes up to five feet diameter, paving slabs, fence posts, building blocks, roofing tiles, a section of concrete road, a number of products for use on the railway, including a station name-plate, level crossing gate posts, station platforms, sleepers and a large number of articles for use on the estate and farm.

At the conclusion of his visit, Mr. Etchells wrote in the visitors' book : " A visit here should be made compulsory for all engineers and architects."

A New Departure.—As our readers are well aware, the Concrete Utilities Bureau regularly exhibits at the Royal Agricultural Show. The success which has attended these efforts year by year suggested an extension of this propaganda work, with the result that a Travelling Exhibit of concrete goods has been equipped for the purpose of visiting various provincial shows during the season.

The exhibits themselves consist of moulds for concrete articles, a pigsty, cowstall, garden frame, fencing of various kinds, gate posts, troughs, tiles, rainwater goods and a number of articles for use on the estate and farm, together with a selection of framed photographs of structures which could not be included in the display itself.

The collection, which is transported by road by means of a steam lorry and trailer, made its first journey in September, and was exhibited at the Altrincham Agricultural Society's Show where it attracted a considerable amount of attention. During the day demonstrations on the moulding of fence posts were carried out and these were watched by a large and interested crowd. On the conclusion of each demonstration there was a great demand for the Bureau literature which was freely distributed.

On the homeward journey the exhibit halted at Stoke-on-Trent, Stafford, Nuneaton and Northampton, at which towns it was inspected by architects, contractors, builders, and, in the case of Northampton where the goods were displayed in the cattle market, by agriculturists.

Concrete Houses at Paisley.—The Paisley Corporation has decided to seek the permission of the Scottish Board of Health to the erection of some blocks of concrete houses, as an experiment.

New Bridges for Norway.—The Norwegian Board of Ways and Water Communications is inviting tenders for the construction and supply of eight bridges for the Iisalmi-Ylivieska Railway. Further information regarding the work required may be obtained from the Dept. of Overseas Trade, 35 Old Queen Street, Westminster, S.W.1 Tenders have to be submitted by November 30.

Cement for the Argentine.—The Argentine State Railways are inviting tenders, to be lodged by November 18, for the supply of cement and other materials. Further particulars may be obtained at the Dept. of Overseas Trade, 35 Old Queen Street, Westminster,S.W.1.

Houses Ready-Made.—According to advices from the United States, buildings are now being moulded in a specially constructed works at Bridgeport, Conn., and when complete are transported by a special motor-car to the site they are intended to occupy.

This novel method is due to Simon Lake, who moulds each house in one piece, using a skeleton of creosoted wood.

The mould shapes the exterior of the walls, the interior being formed by caissons covered with asphalt.

After the concrete has been placed, hot air is passed through the caissons, so that the asphalt melts and the caissons are withdrawn. Sufficient asphalt adheres to the concrete to render the latter impermeable to water.

The walls are very thin—only about 6 in. for the external walls, and 1 in. or less for internal ones. The thinner ones may be made by coating an expanded metal of lattice sheet with concrete from a cement gun or similar material.

Lightness of construction is regarded as of prime importance ; the houses already built do not exceed 15 tons each in weight.

Ballantyne Pier, Vancouver.—Designed to berth four 600-ft. vessels, the new Ballantyne Pier at the port of Vancouver is now well under way. This pier is being built on the most approved modern plan and will be equipped with the latest type of cargo-handling equipment. The superstructure is to rest on reinforced concrete cylinders sunk to rock by open dredging, all concrete work below high water being pre-cast. Twelve hundred feet in length by 340 ft., the massive superstructure will rest on a solid and permanent foundation. The specifications also include a shore quay 936 ft. by 350 ft., in the construction of which 7,000 tons of fireproof steel and one-quarter million barrels of cement will be used. The outer berths will be dredged to a minimum depth of 45 ft. below ordinary low water. Four two-storey transit sheds, 500 ft. by 110 ft., constructed of reinforced concrete, will be equipped with electric elevators and adequate cargo-handling appliances. Included in the plan is a roadway for vehicles between the sheds in the centre of the pier, in addition to two railroad tracks on the outer sides. Semi-portal electric cranes are proposed for installation on the outer platforms. The total cost of the Ballantyne Pier, including that of the site and equipment, will be in the neighbourhood of 6,000,000 dols. It is expected that the work will be completed within two years' time.

The Use of Steel Forms for Concrete Columns and Floor Slabs.—While steel forms have been widely used for such work as tunnels, culverts, sewers, etc., the employment of such forms for constructing flat slab floors and columns is not so general. An interesting example of their use has recently occurred in connection with the erection of the Columbia Graphophone Company's new building in Baltimore, which is described in the *American Architect*. This is a seven-story structure with a floor area of about 8,400 sq. ft., or a total of about 670,000 sq. ft., including the roof. The columns are spaced 20 ft. on centres and the drop panels at the column heads are 8 ft. square. The floor slabs are 9 in. thick and the round columns vary from 40 in. in diameter in the basement to 16 in. on top floor. Formwork was started at both ends and moved towards the middle, so that when concreting was finished in the middle portion forms were again ready for concreting at the two ends.

The system of shoring as employed with the steel forms was such as not to require re-shoring ; and due to the fact that the steel forms would not permit of seepage of cement to the shoring below and that practically no nails were required, the lumber used for this purpose was remarkably clean at the completion of the job and had a high salvage value. However, the outstanding feature was the fact that it was necessary to purchase and expend or destroy less than one-fifth of the lumber that would have been destroyed if lumber alone had been used.

After the shoring was erected the steel panels were placed. These were made of No. 14 gauge pressed steel in two standard sizes, 6 ft. long by 2 ft. wide and 6 ft. long by 1 ft. wide, and so designed as to carry the maximum imposed load when supported at the ends.

The steel panels, after being placed, received a brush coat of light paraffin oil, after which the reinforcing steel was placed, the inserts set and the concrete poured. In connection with the setting of inserts, a small hole was drilled in the desired loca-

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tions through the steel panels, a small breast drill being used for the purpose with a bit on a shank long enough so that it could be operated from a standing position, a very few turns being necessary to drill through. The inserts were then held in place by the use of a barbed fourpenny nail driven into the hole. This held the inserts securely and the resultant holes were so small as not to affect the appearance of concrete poured on the panels when re-used.

The system of laying steel panels was so laid out as to leave very few spaces requiring patching and these were taken care of by laying down strips of steel sheets of required width and length.

All interior columns were round with bell shaped heads. These were formed with steel forms adjustable to height and diameter. The surface of the steel coming in contact with the concrete was coated with light paraffin oil, which not only prevented the concrete from adhering to the forms, but materially affected the resultant finish on the concrete columns, leaving them with a smooth, glazed finish. The same finish was obtained on the ceilings.

The concrete columns and ceilings were painted ; and it may be interesting to note that, due to the glazed finish obtained by the use of steel forms, it was necessary to use but one-half of the quantity of paint originally estimated.

In the application of the system of forming used on this operation, it was necessary to make some slight changes in the panel lay-outs and sizes of depressed heads as originally shown on the architectural drawings, in order to make the entire floor plan standardised. Such changes can generally be made in adapting almost any flat slab structure to the use of steel forms in construction.

Throughout the entire job, the steel forms proved themselves adaptable to every requirement.

Concrete Motor Ships.—The Danish firm Koege Vaerft has delivered a new reinforced concrete motor ship *Poseidon* to the Triton Shipping Company, Copenhagen, and the trial trip in the Sund proved, it is reported, in all respects satisfactory. The dimensions of the vessel are : Length, 60 m. ; breadth, 10 m. ; draught, 4.75 m. Her carrying capacity is 1,300 tons deadweight, and she is a sister ship to the *Triton,* delivered in October last. The motive power is a four-stroke six-cylinder Diesel engine of 400 horse-power. The oil tank holds 40 tons, and as the boat only consumes about 1½ ton daily, she carries enough oil for at least twenty-six days. Her normal speed when loaded is 8 to 8½ knots. The vessel's first journey will be to Kiel, where she will load for Glasgow. At a lunch in celebration of the delivery of the *Poseidon,* a representative of the Triton Company stated that the company's experience with the sister ship had been extremely favourable in all ways, so much so that it had been possible to keep her running at a profit ever since she was delivered. This fact was to be ascribed in the first place to her excellent and economical machinery. It would have been impossible, said the speaker, to keep a steamship of similar size running during the same period at the freight rates obtainable.

Water-tight Joints for Tank Walls.—Mr. B. E. Aldrich, in our contemporary, *Concrete, U.S.A.*, makes a suggestion for a water-tight joint, where it is impossible to complete the tank by continuous pouring. An inverted bell is poured when stopping at the end of the day's work. A space of not less than 1 in. is suggested to be filled in with asphaltum or some other suitable material, this space to be 2 in. or 3 in. deep. When pouring is started again the wall of the tank is carried up the same thickness as below the bell, and resting directly on the previously poured concrete. The asphaltum in the space between the inner face of the tank and the bell is suggested to provide for a waterproof joint. It is assumed that the pressure of the water will be met by the asphalt, which will act as a calking and thus leakage at the joints will be prevented.

The tank in which it was proposed to use this type of joint was 10 ft. in diameter by 20 ft. high.

The Air Ministry and the Grissell Prize offered by the Royal Institute of British Architects.—The Air Council have signified their warm appreciation of the decision of the Council of the Royal Institute of British Architects to award the Grissell Prize this year for the best design of an *airship mooring mast.* The prize consists of a *gold medal* and the *sum* of *£50.* The competition is open to architects who are

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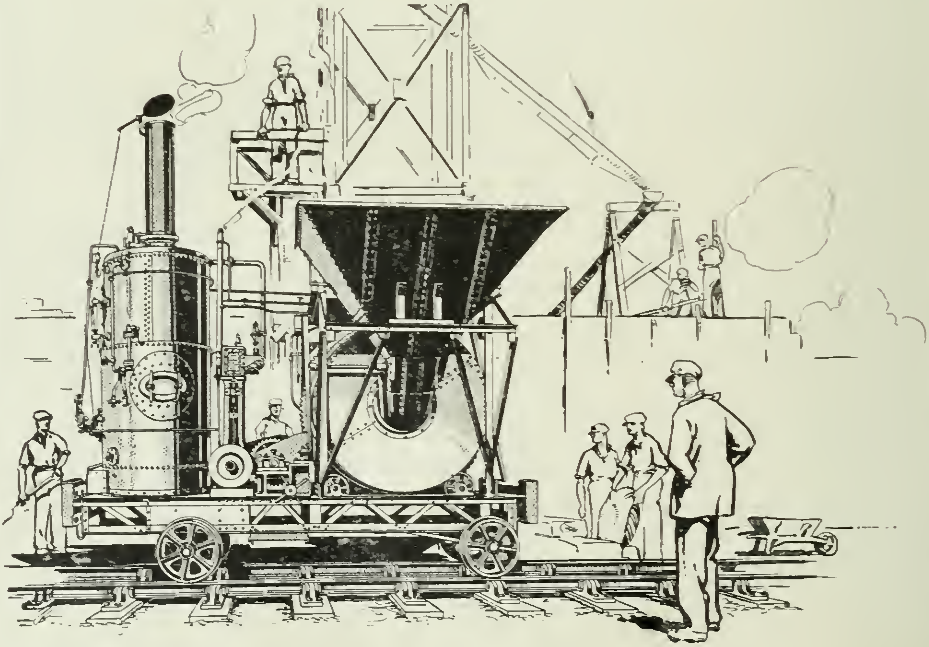


British subjects and have not been in professional practice for more than ten years. As a further indication of their interest in the competition the Air Council have asked that facilities shall be given them to see the more promising designs submitted by competitors, and express their readiness to nominate an expert to give his assistance to the Grissell Prize Committee on any points in which actual airship experience would be of value.

TRADE NOTES.

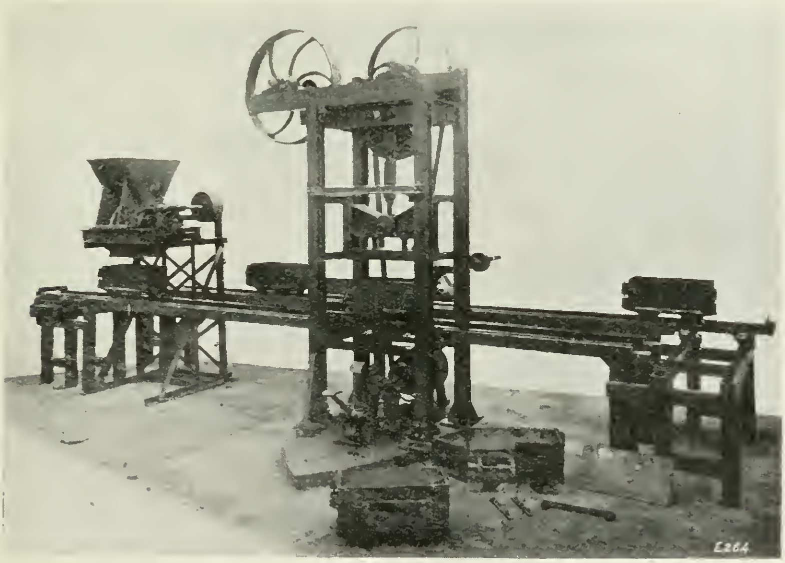
The Champion Block and Slab Maker.—This new machine has recently been put on the market by Messrs. R. H. Kirk & Co., Collingwood House, St. Peter's, Newcastle-on-Tyne.

In addition to making slabs, rock-faced blocks can be easily made on this machine. The arrangement of the machine is as follows: the moulding box is so made that the inner linings are not detachable, but are so arranged that they retract from the stone prior to rising away, which gives an immediate release and obviates the necessity of hauling the stone, except for carrying it away to mature.

We understand that the time actually required for the operation of making and discharging the block is only 20 seconds. One set of pallets answers for all sizes of blocks or slabs from 2 in. thick up to the maximum made on the machine.

It is claimed that one man and a boy can turn out 90 slabs or rock-faced blocks per hour, or any size up to 18 by 9¾ by 4½ in. thick.

The Glutton Block-making Machine (Patented in Great Britain, France, Belgium, Germany, the United States and Canada).—The special features of this machine are said to be its speed, efficiency, simplicity and economy.



It is a power-driven machine; strongly built, simple to operate, can be fixed anywhere, and any kind of material such as ballast, shingle, clinker, sand, breeze, etc., may be used.

The method of procedure is as follows: The aggregate is put into the hopper (shown in the accompanying illustration) where the exact quantity needed for the size slab to be made is measured off by a revolving cylinder and deposited into one of the mould boxes or trucks. The truck then passes under the press (where the slab is formed) and away on the track, the slab is taken out and the truck returned for a repetition of the operation.

It is claimed that more than 350 slabs, equal to 1,750 bricks, can be made per hour, and that two men and two lads can do all the needed work in connection with the actual making.

The quoted output is estimated for slabs 18 in. by 9 in. by any thickness within the limits of the mould box. Wood or iron pallets may be used.

Demonstrations will be given at any time by appointment at Hamlett's Offices, 764 Barking Road, Plaistow, E., fifty yards from the Boleyn Tavern.

A New Form of Shuttering.—Our attention has been called to the "Easiform" system of constructing concrete houses. The basis of construction is a light but strong form 6 ft. by 2 ft. by 3½ in. All the forms are standardized with the exception of the four corner forms of each block and closures. The method of construction is briefly as follows: When the first row of forms is set in position they are filled with concrete and the second row placed on and secured to them and to each other by bolts or pins. It is claimed that to place and accurately fix a pair of forms, when all is favourable, only two men are needed and the time occupied is 1 minute.

When the second row is filled with concrete, the first is removed and at once placed and secured on to the top of the second row, thus forming the third course, which process is repeated up to roof height.

Each course is 2 ft. high, and the work is most economically managed when the gang is such that they can complete one round of a block of houses for both shuttering and concrete in a day.

Houses have been erected on this system at Wrexham and Hereford.

We understand that the system depends on a carefully designed method of scaffolding by means of uprights and iron putlogs engaging with the shutters, which enables the lifting to be done at the necessary pace without interfering with the construction. The walls are usually of cement concrete wet mixture with a clinker aggregate, finished on the outside with waterproofed cement render and rough-cast. Full particulars may be obtained from Messrs. John Laing & Son, Ltd., 3–4 Lincoln's Inn Fields, W.C.2.

TENDERS ACCEPTED.

Barn Elms.—Messrs. Leslie & Co. have received a contract for the construction of a reinforced concrete filter and other work at Barn Elms for the Metropolitan Water Board, for the sum of £15,410 18*s.* 3*d.*

Doncaster.—The Doncaster Town Council has awarded a contract to the Unit Construction Co., Ltd., of London, for the erection of 24 "Type B.S." houses for £18,906 1*s.* 4*d.*, and 72 "Type B.N." houses for £56,973 4*s.* 2*d.*

London.—The London County Council has awarded a contract to Messrs. F. & T Thorne for the construction of an ambulance station at Woolmore Street, St. Pancras. The building is to be built of concrete, at a cost of £1.579. The tenders received for the work were as follows:—(1) in concrete; (2) in timber and glavanised iron: F. & T. Thorne, (1) £1,579, (2) £1,579; C. P. Roberts & Co , Ltd., (1), £1,716, (2) £1,549; J. McManus, Ltd., (1) £1,767, (2) £1,687; John C. Mather, (1) £1,828, (2) £1,623; William Harbrow, Ltd., (1) £2,070, (2) £1,677.

Market Drayton.—The following tenders have been received by the Market Drayton Urban District Council for the erection of 24 houses:—Roberts (Birmingham), Ltd., Birmingham, £16,732; A. W. Felton, Eccleshall, £16,776; A. H. Woodhouse, Shrewsbury, £16,800; Ball & Sons, Stoke-on-Trent, £17,194; Building Guild, Manchester, £17,555; G. Jackson, Tipton, £17,255; Unit Construction Co., London, £17,842; France Bros., Wellington, £18.336. The tender of Messrs. Roberts (Birmingham), Ltd., has been accepted.

PROSPECTIVE NEW CONCRETE WORK.

Aberdeen.—*Aqueduct.*—The Aberdeen Corporation is considering the question of building a new aqueduct at a cost of £53,000, and has been recommended by a committee to proceed with the work at once.

Alsagar.—*Waterworks.*—The Ministry of Health has sanctioned the borrowing by the Alsagar Urban District Council of the sum of £5,242 for water supply works.

Barrow-in-Furness.—*Car Sheds.*—The Ministry of Transport has santioned the borrowing by the Barrow-in-Furness Town Council of £16,000 for the provision of further tramway car sheds.

Bideford.—*Waterworks.*—Ministry of Health sanction has been received by the Bideford Town Council to a loan of £43,178 for the purpose of the development of the water supply. The sum includes £38,217 for constructional works.

Birmingham.—*Waterworks.*—An application of the Birmingham Corporation for sanction to borrow £150,000 for waterworks purposes has been sanctioned by the Ministry of Health.

Birmingham.—*Reservoir.*—The Birmingham Corporation has decided to promote a Bill in Parliament for the construction of a service reservoir at Frankley.

Brockenhurst.—*Sewage Works.*—An inquiry has been held by the Ministry of Health into the application of the Lymington Rural District Council for sanction to borrow £20,367 for sewage disposal and other works.

Burnham (Essex).—*Reinforced Concrete Tank.*—The Ministry of Health has sanctioned a loan by the Burnham Urban District Council for the construction of a reinforced concrete storage tank at the waterworks.

Cambridge.—*Sewage Works.*—The Cambridge Corporation has decided to proceed with the construction of various sewage works, at a cost of about £40,000.

Chester.—*Bridge.*—The Chester Town Council has decided to apply for sanction to borrow the sum of £3,000 for the purpose of repairing or replacing the Queen's Park suspension bridge.

Chingford (Essex).—*Reservoir.*—The Chingford Parish Council has under consideration the question of constructing a storage reservoir in connection with its water supply.

Cowes.—*Reservoir.*—The East Cowes Urban District Council has decided to apply to the Ministry of Health for financial aid towards the construction of a new reservoir.

Derby.—*Reservoir.*—The Derby Town Council is considering a proposal to construct a new service reservoir at Drumhill.

Dovercourt.—*Sea Defence.*—The Dovercourt Town Council has decided to proceed with the construction of a sea wall and other works, at a cost of £10,250.

Girvan.—*Reservoir.*—The Girvan Town Council has decided to apply for a provisional order to purchase about 120 acres of land for the construction of a reservoir.

Haslingden.—*Sewage Works.*—An application has been made to the Ministry of Health by the Haslingden, Rawtenstall and Bacup Sewerage Board for sanction to a loan of £25,500 for extensions at the outfall works.

Hendon.—*Open-air Bath.*—A proposal to construct an open-air swimming bath near the Welsh Harp is being considered by the Hendon Urban District Council.

Heywood.—*Lake.*—The Heywood Corporation has decided to apply to the Ministry of Health for sanction to the borrowing of £7,200 for the purpose of constructing a boating lake.

Holmfirth.—*Sewage Works.*—The Holmfirth Urban District Council has decided to apply for a loan for the purpose of carrying out a scheme for the extension of the sewage works, including the construction of storage, detritus and other tanks.

Kirkcaldy.—*Sea Wall.*—The Kirkcaldy Town Council has been recommended by a committee to proceed with the erection of a sea wall and esplanade, at an estimated cost of £100,000.

London (Lewisham).—*Open-air Bath.*—The construction of an open-air bath at Ladywell is under consideration by the Lewisham Borough Council.

Newcastle-on-Tyne.—*Open-air Bath.*—The Newcastle-on-Tyne Corporation has been recommended to construct an open-air bath at Jesmond Vale, at a cost of £9,000.

Newport.—*Road.*—The Chepstow Urban District Council has decided to construct a new road between Newport and Tintern (Mon.), at a cost of £80,000, three-fourths of which is to be supplied by the Ministry of Transport.

Peterborough.—*Sewage Works.*—A new sewage disposal scheme is to be carried out by the Peterborough Town Council, and the first part, estimated to cost £10,500, is to be proceeded with at once.

Rhyl.—*Sea Wall.*—The River Clwyd Drainage Board is considering a proposal to construct a concrete sea wall between Foryd and Abergele, at a cost of £2,450.

Ringwood.—*Road.*—The Ringwood Rural District Council is to proceed with the construction of a new road from Bagnam to Crowe.

Stamford.—*Sewage Works.*—The Stamford Town Council is considering a scheme for the improvement of the sewage works, at an estimated cost of £8,000.

Stockport.—*Waterworks.*—The Stockport Town Council has received the sanction of the Ministry of Health to an application to borrow £33,185 for extensions to the water supply.

Stockport.—*Filters.*—The Ministry of Health has held an inquiry into the application of the Stockport Town Council for sanction to a loan of £15,000 for the provision of eight filters at the Kinder reservoir.

Stoke-on-Trent.—*Sewage Works.*—An inquiry has been held by the Ministry of Health into an application of the Stoke-on-Trent Town Council for permission to borrow £13,000 for sewage disposal and other works.

Wakefield.—*Sewage Works.*—An inquiry has been held by the Ministry of Health into an application of the Wakefield Corporation for sanction to a loan of £22,500 for the purpose of remodelling the sewage works.

Watford.—*Reservoir.*—The Watford Urban District Council is considering the construction of a new reservoir and other water supply works, at a cost of £93,000.

NEW COMPANIES REGISTERED.

Ingersoll-Rand Co., Ltd. (176,447). Registered August 24. Manufacturers of plant for mining, tunnelling and quarrying, tools, implements, and all kinds of machinery. Nominal capital, £100,000, in 100,000 £1 shares. Directors: W. M. Treglown & D. McP. Armstrong, 165 Queen Victoria-street, E.C.; F. A. Choffel; J. P. Eyre; L. Speck; and P. J. Murphy. Qualification of Directors, 1 share; remuneration to be voted by Company.

Epsom Brick & Tile Co., Ltd. (176,747). Registered September 12. Manufacturers of concrete, bricks, and pipes. Nominal capital, £10,000, in 10,000 £1 ordinary shares. Directors to be appointed by subscribers. Qualification of directors, one share; remuneration to be voted by company. Subscribers: E. E. Elmore, "Arden," Meadway, N.W.; and C. Russell, 221 Hampton Road, Ilford, Essex.

RECENT PATENT APPLICATIONS.

142,824. O. Kilp: Building blocks.
144,645.—C. H. Schol: Manufacture of building blocks.
146,377.—C. S. Howell and L. MacGuire: Concrete piles and method of pile driving.
150,994.—C. Candlot: Kilns for lime and cement.
159,502.—Societe Anon. Collectif, M. Monnever and H. T. E. Kirkpatrick: Expansion joints for concrete roads.
166,623.—W. Christmas: Concrete building blocks.
166,630.—B. Bradley: Reinforced concrete pipes.
166,633.—W. H. Smith: Concrete blocks and bricks.
166,706.—W. F. Scott: Reinforced concrete building construction.
166,741.—D. C. Patterson: Concrete wall construction and centering therefor.
166,753.—J. F. Hunt and L. V. Caesar: Building blocks and wall construction.
166,826.—G. de Ridder: Reinforced paving of roads, etc.
166,978.—T. W. Armstrong: Machine for the manufacture of concrete blocks.
167,017.—G. Kuchler-Bareth: Hollow building blocks and walls.
167,070.—R. C. Metcalfe: Continuous tunnel kilns.
167,273.—A. L. Woodward: Shuttering for concrete construction.
167,276.—F. F. Osgood & S. H. West: Interlocking concrete blocks.
167,356.—D. C. Fidler: Wall construction.
167,875.—W. K. Wise: Shuttering for reinforced concrete buildings.
167,888.—F. M. Tozer and L. J. Pond: Wall construction.
167,972.—A. S. Adams: Machine for making concrete blocks.
168,082.—E. J. Felt: Pilasters, piers, etc., and blocks for their construction.
168,126.—M. R. Sheen: Sewer and tunnel building machine.
168,168.—A. Walker: Building blocks.
168,172.—W. Forbes: Concrete block-making machine.
168,258.—I. Shingleton: Shuttering for the construction of concrete buildings.
168,267.—W. Christmas: Concrete brick and block-making machine.
168,416.—S. F. Dampney: Concrete building slabs.
168,446.—W. and W. W. R. F. Griffiths: Buildings of concrete blocks.
168,616.—R. H. Rogers: Structural members for reinforced concrete buildings.
168,631.—M. B. Biside: Method of moulding concrete.
168,711.—G. Yamanouchi: Building blocks.
168,714.—J. B. Harvey: Manufacture of concrete blocks.
168,774.—J. Vaughan: Cement.
168,992.—H. C. Eisel and W. B. Etherington: Concrete building slabs and blocks.
169,043.—W. H. Roughsedge: Moulds for manufacture of concrete blocks.
169,071.—A. Wood Hill: Method of imparting elasticity to reinforced concrete railway sleepers.

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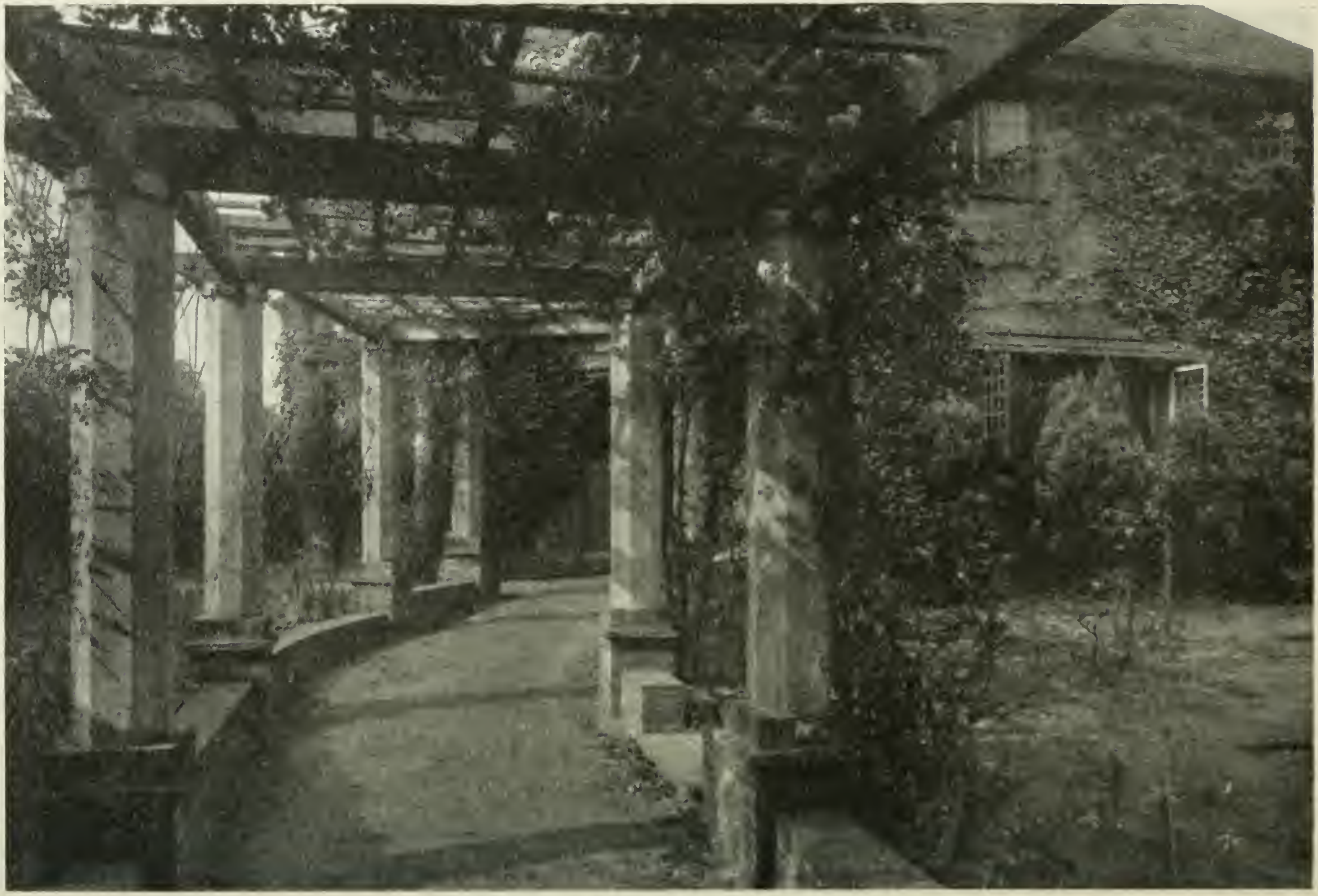

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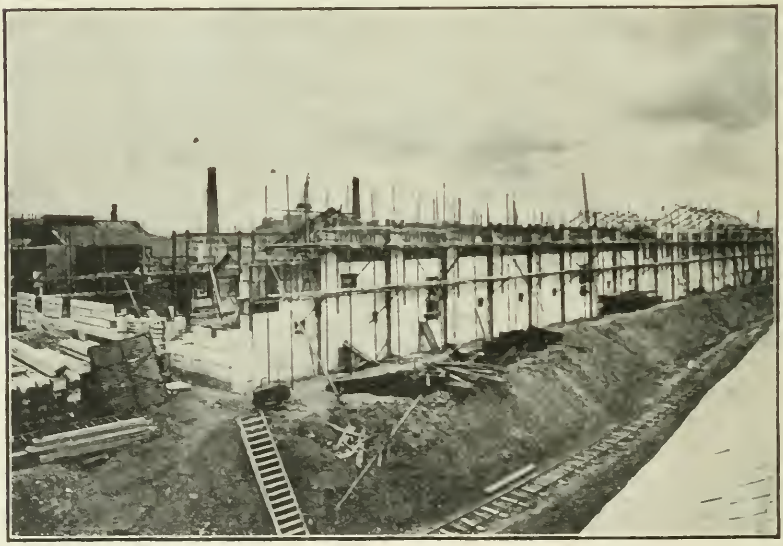

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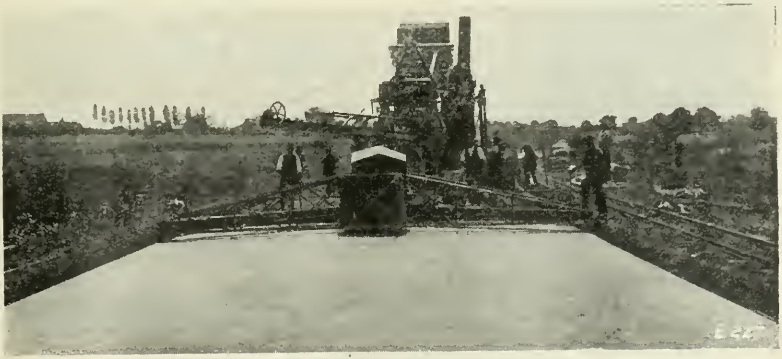

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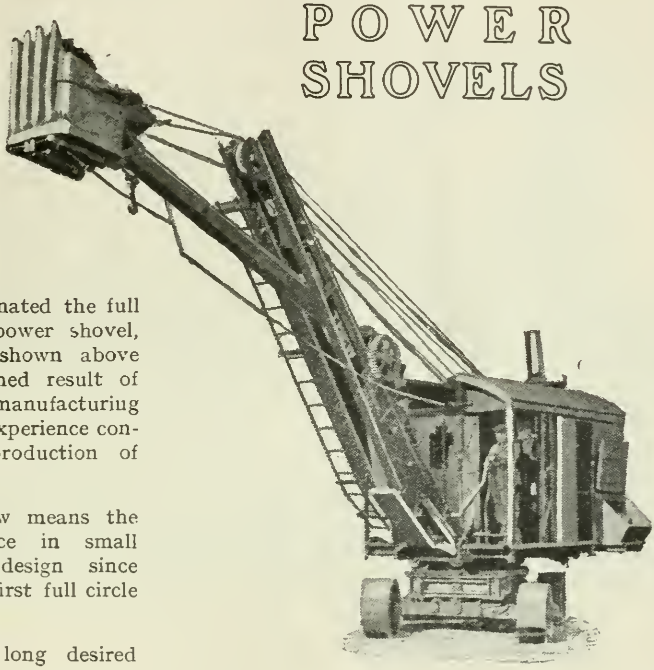

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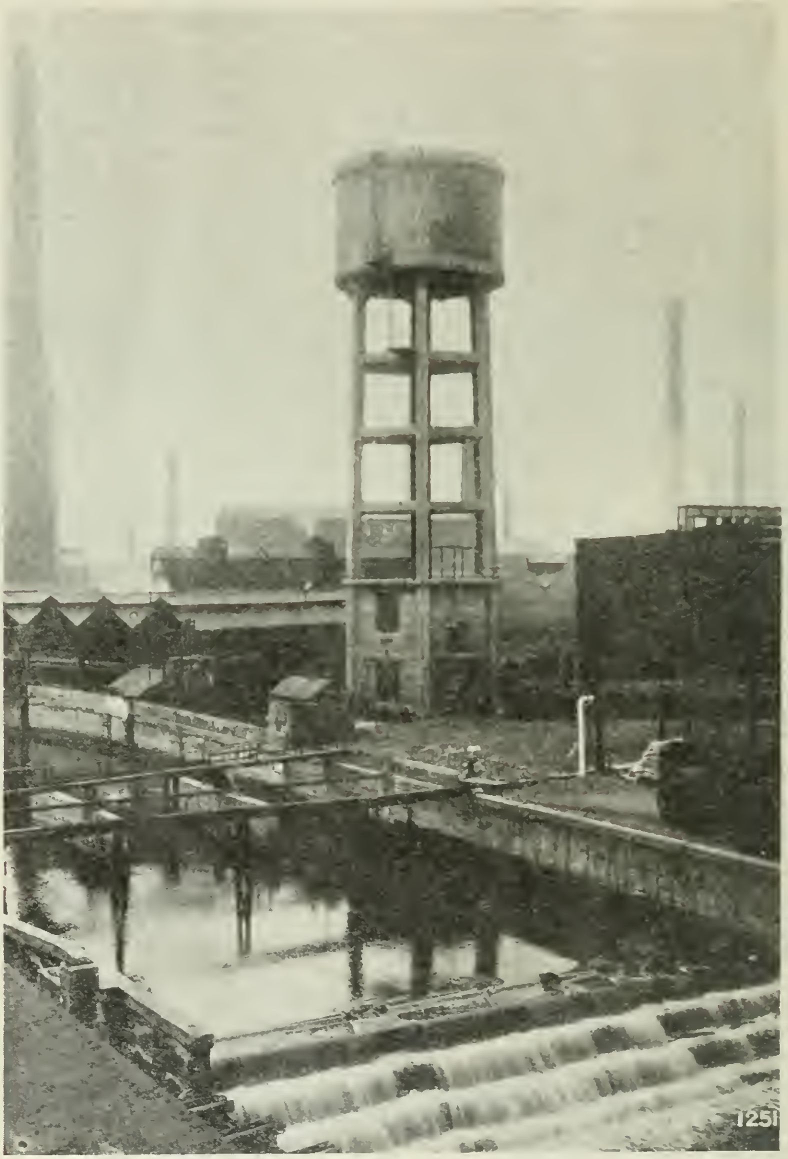

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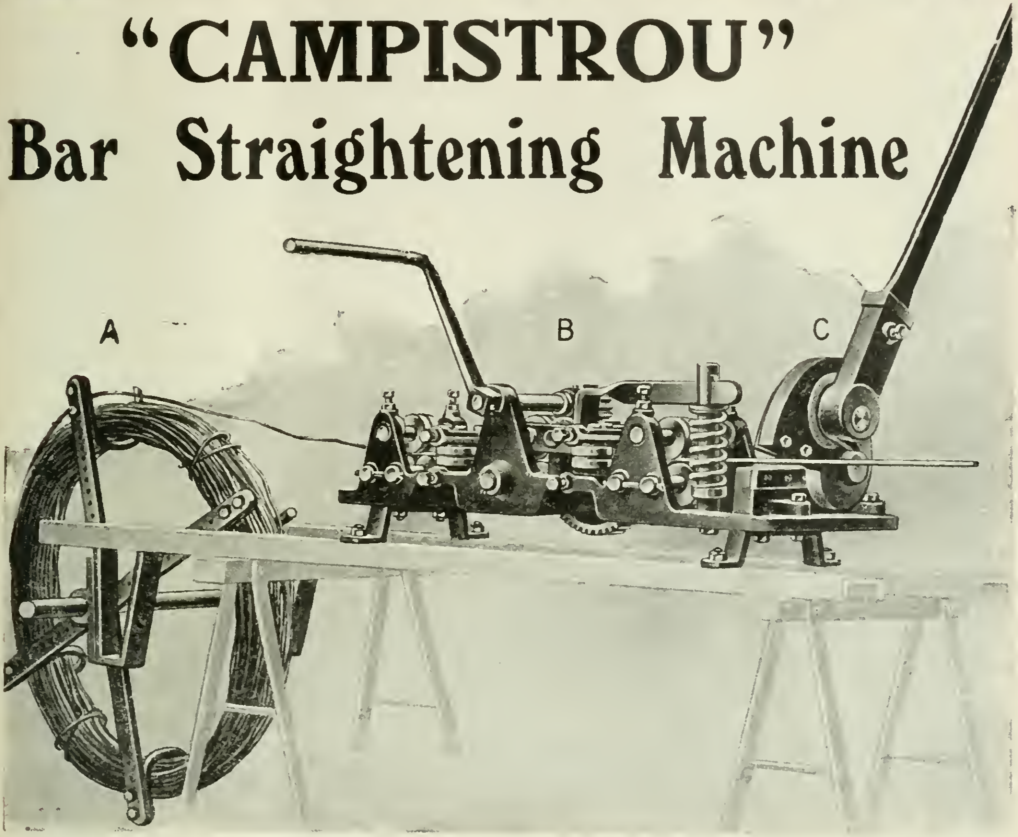

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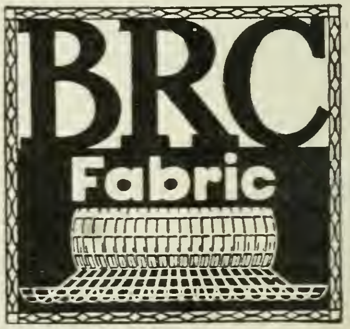

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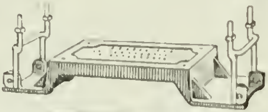

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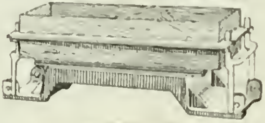

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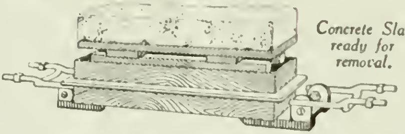

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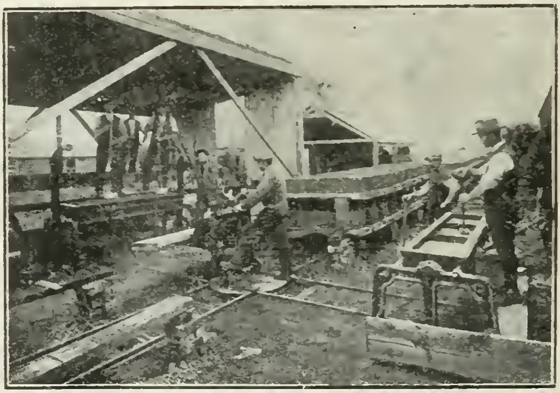

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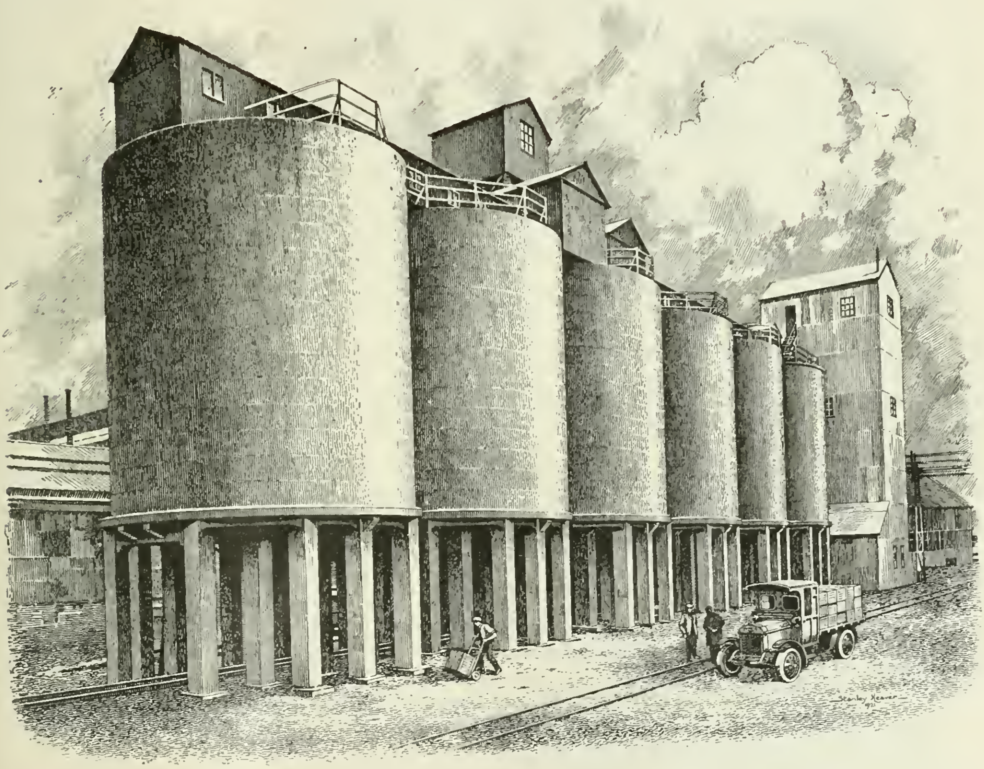

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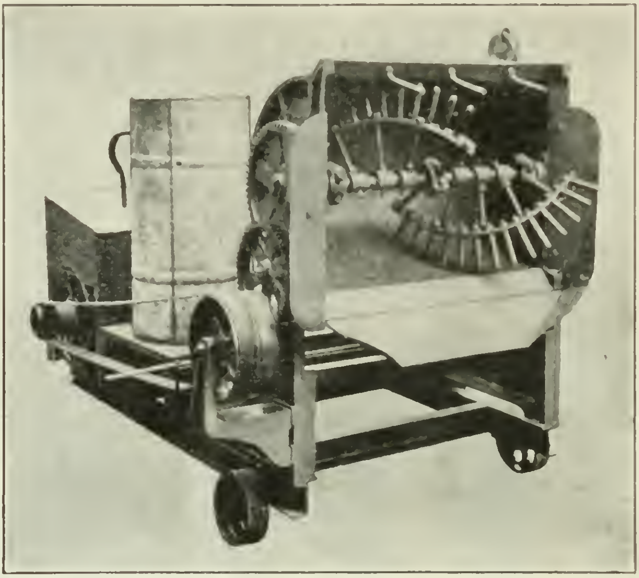

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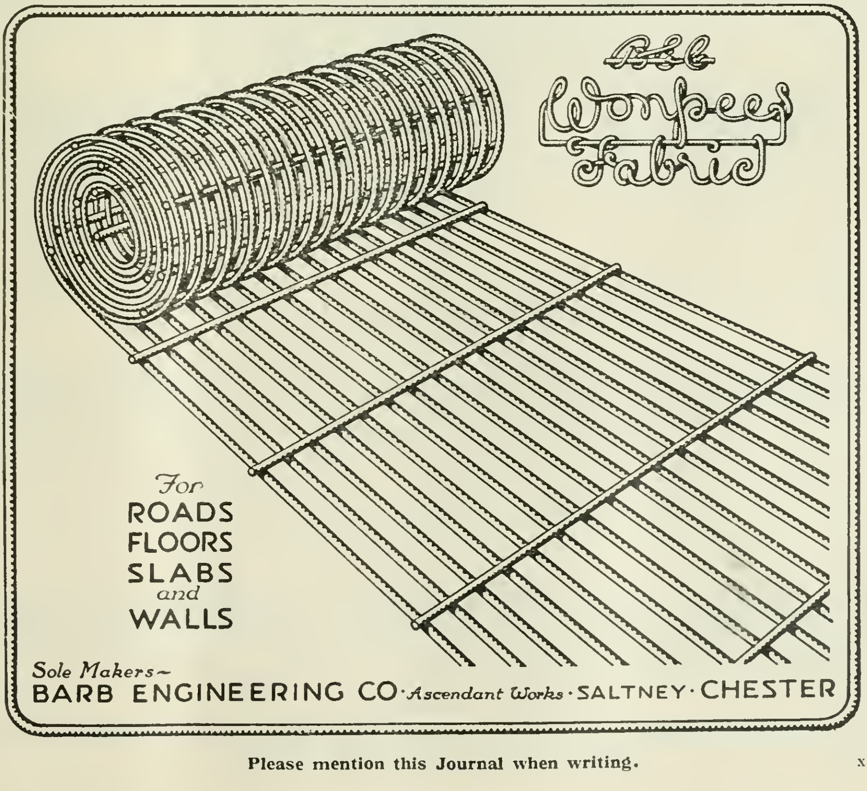

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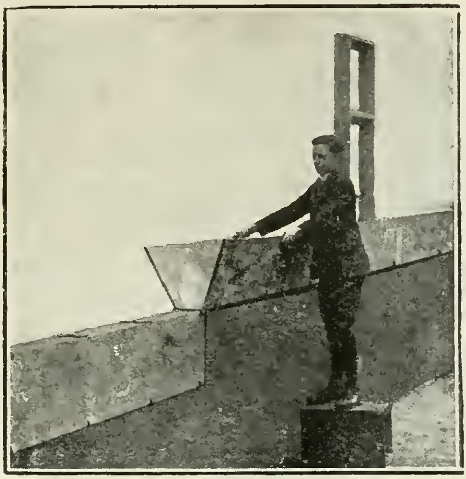

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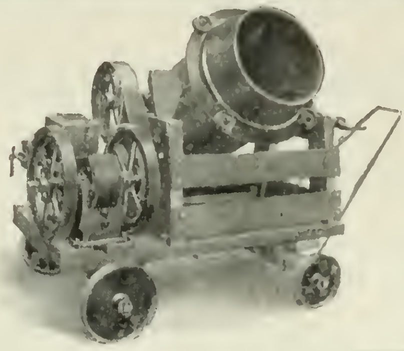

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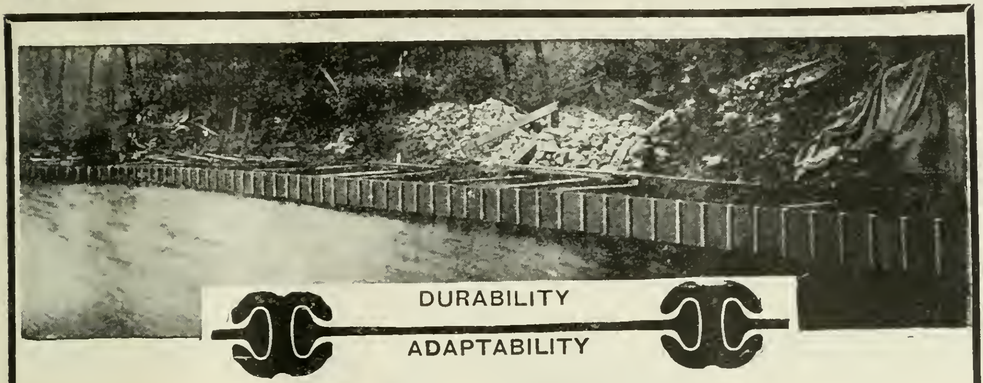

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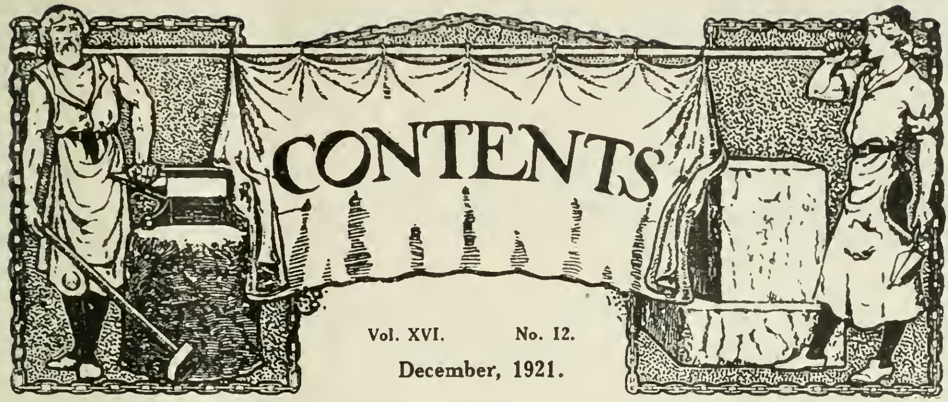

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CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XVI. No. 12. LONDON, DECEMBER, 1921.

EDITORIAL NOTES.

THE DEPARTMENT FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

THE report of this department for the current year, now in our hands, though it does not contain much of direct interest to our readers, is yet worthy of notice, inasmuch as all research work in the field of natural science has considerable indirect value, even for those interested in but few materials. The most important event from our standpoint is the definite beginning of operations by the Board of Building Research which, at East Acton, has established an experimental station under the direction of Mr. H. A. Weller. Notwithstanding the research activities of the Concrete Institute, there are many problems in connection with cement and concrete which await solution, and the existence of this new Board will presumably lead to a consideration of these problems.

The Department appears to be doing useful work in the sphere of co-ordination. There is a great tendency for researches to overlap, due to the isolation of workers, and any means for reducing this waste of effort should certainly be sought for and supported. Activities appear to have been somewhat curtailed owing to the material need for economy, but whether it is really economy to reduce expenditure on research which invariably ends in some valuable additions to knowledge and eventually to trade and industry, we very much doubt.

If research results in knowledge, that knowledge should be available for the general welfare, and in order that it may be utilised industrially for more economical and efficient production, which will enable us to take our place in the world's commerce; and, as a result, our external trade will increase; and this, in its turn, will lead to greater prosperity. The message of science must be carried to the public so that it may see, through its parliamentary representatives, that "economy" which puts a check on efficiency is not practised, and this message means more science in general education.

Most of the activities of the Department cited in this report are too indirectly concerned with our sphere to justify description here, but we shall always be pleased to give prominence to subjects in these reports of interest to our readers, and hope to be kept in touch with results likely to benefit experimenters upon cement and its many uses.

THE SURFACE DECORATION OF CONCRETE.

A PAPER was recently read by Mr. Bylander before the Liverpool Architectural Association on "Concrete." The Paper was full of useful information regarding the material, its nature and properties, and its contents are well summarised at the end in a series of suggestions which the author has called "Dont's" and these suggestions, although containing nothing new for the practised concrete worker, are perhaps worth repeating for the benefit of our many student readers, and, therefore, we reproduce them in another part of this issue.

There is one point, however, in Mr. Bylander's paper which we feel should not pass unnoticed, especially in view of the fact that it was addressed to architects. In his early remarks Mr. Bylander states that "concrete is durable and reliable if suitably used, but it cannot compete with natural stone for appearance because of its depressing colour, which does not improve with age, and its uninteresting surface. Later on he says "a good and *successful* * example of external treatment of concrete by colour scheme is that of a factory at Garston where the concrete exterior was made more interesting by the introduction in parts only of bright differently coloured glazed tiles and ornaments which give more cheerfulness to the elevation."

The question of the surface treatment of concrete is one that has been occupying the minds of all interested in concrete construction for a long time past, and no impartial critic would refute the first statement quoted from Mr. Bylander's Paper if that were all that is to be said on this matter. But we feel this is dismissing the question in a very summary way and without having the least regard to what has been done in research and practice to remedy what appeared, at one time, to be an insurmountable difficulty. But no account seems to be taken in the paper of the many ways in which this difficulty may quite legitimately be overcome. We will refer to one only here which has been used successfully both for large buildings as well as for smaller structures: we mean the use of a coloured aggregate in the surface concrete; when the concrete has well set it is tooled or brushed in order to reveal the aggregate, whereby a pleasing and warm looking surface can be obtained. There are other methods, which have been described in these pages many times, of relieving this colourless effect and which do not in any way disguise the material used. We doubt very much whether the treatment of the factory at Garston, to which the author points, is one which would approve itself to the architect or engineer as being a legitimate one to adopt in architecture where purity of style is aimed at. As we have so often pointed out, the thing to be striven for is a treatment which is native to, and inherent in, the material employed.

THE PROBLEM OF COLLABORATION.

Mr. Page's recent articles on "The Decorative Treatment of Concrete," which have appeared in our columns, have produced an interesting letter from Mr. Harry Jackson, which is published elsewhere in this issue. Our correspondent, whilst admitting that a wise collaboration between architect and engineer for the production of a reinforced concrete building is the ideal procedure, wonders how this arrangement is to be achieved. Is the architect to employ the engineer, or *vice versa*; or, worst of all, is the engineer designer to be employed by the building contractor?

The situation in itself, is, surely, not a new one, the novelty lies only in its application, and we can find guidance in analogous cases. As the complexity of modern industry increases, and as the fields of scientific discovery and invention extend, so the necessity for specialisation grows ever more emphatic, thus we find a secession amongst certain of the functions once performed by the architect and a growth of subsidiary professions. As an example of this may be cited the quantity surveyor, and to-day no building-owner demurs at the payment of the fees of a quantity-surveyor for the specialised services which he renders. He is, however, neither employed by the architect nor by the building contractor (except on small jobs where a builder may take off his own quantities before tendering).

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* The italics are ours.

Another example is afforded by the consulting electrical engineer. The perfect architect would doubtless be capable of designing and supervising the work in connection with the most complex installation. In practice, however, he advises his client to employ the services of a specialist to perform work the technical nature of which he frankly admits to be outside his province. In many cases, we know, the building owner prefers to leave the whole matter in the hands of the selected contracting firm of electrical engineers, but such a course, at any rate for big jobs, is becoming less frequent, and thus we have a simple case of collaboration between the architect and the electrical engineer. It is along these lines, then, that the ideal collaboration suggested by Mr. Page must be sought.

There is, however, another aspect to the matter. It will happen that where the work under contemplation be more specifically of an engineering character, such as, let us assume, a bridge, a viaduct, a dam, or a reservoir, it will be the engineer whose services will be enlisted at the outset, and upon him will rest the onus of advising his client to employ an architect who, by training and temperament, will be able to supply that knowledge and technique required to produce a work of strength and beauty.

It is perhaps no exaggeration to say that the same kind of collaboration is to be found in other professions, for are not those of the dentist and anæsthetist, the solicitor and barrister, somewhat akin ? However, realising, as we do, that the particular partnership at which we are aiming has as yet to be firmly established, we shall be glad to publish the opinions of other architects and engineers as to the best methods of establishing this co-operation as a recognised practice, and any experiences that they may have had of co-partnership on these lines in the course of their professional work.

GENERAL NOTES.

NOVELTIES IN CONCRETE WORK.

Automatic Records of Concreting Operations.

In connection with some recent structural work at Milwaukee where 24,000 cubic yards of concrete had to be placed, the usual American equipment of hoisting tower and gravity shutes was employed. The hoist was driven by an electric motor, and a recording watt-meter showing the power consumed by the motor was included in the circuit, the record chart being in the resident engineer's office. The chart showed not only the intervals between each hoist of the concrete skip, but also indicated whether the weight of the material in the skip was varying. The speed of the concreting was thus recorded, and any slacking off could at once be seen by the engineer and investigated when necessary. This may be taken as another example of the American's capacity for saving labour.

It is conceivable that this system of automatic records of concreting could be extended. Automatic recording weighing machines are in use in certain manufacturing operations, and it would not be difficult to arrange such machines for the weighing of cement and aggregate so that a definite record was obtained of the respective quantities of these two materials used in any period, thus checking the accuracy of the proportions.

If an inventive mind could design an apparatus for recording the consistency of concrete as it left the mixer, it would be a real service to the community.

Providing for Expansion in Concrete Roads.

It is only in those parts of the world where extreme differences in temperature occur that any provision is needed for expansion, and where such provision is not made it occasionally happens that the concrete surface buckles upwards. To minimise the effect of this, a system of steel dowels is now being adopted.

These dowels—5 ft. rods of ¾ in. diameter and usually about five in number—are embedded longitudinally for about half their length in the concrete at the end of a day's work, and the next day the projecting ends are greased and wrapped in paper so that the concrete placed over these ends does not adhere to them. The result is that the rods are fixed in one slab of concrete, and are free to move slightly in the adjacent slab when any movement, due to expansion with increased temperature, occurs.

Instead of being placed at "construction joints," i.e. the joints between successive days' work, the dowels can if preferred be placed at specially provided contraction joints at definite spacings.

Belt Conveyors for placing Concrete.

Portable conveyors for handling material such as roadstone or small coal from storage heap to railway wagon or *vice versa*, are becoming fairly well-known in this country and are greatly appreciated as labour-savers. These machines usually consist of a bucket conveyor (belt or chain) mounted on a pair of wheels for portability and driven by an electric motor or petrol engine carried on the same framework.

Portable conveyors have now been applied in America to the placing of concrete, and they apparently form an intermediate stage between the costly steel tower hoist with gravity shutes and the laborious method of placing concrete by hand with wheelbarrows and runways. For concrete walling, a combination of a mixer discharging on to a portable belt conveyor suggests a most economical method of working which is worthy of close consideration.

Concrete Tanks for Carbolic Acid.

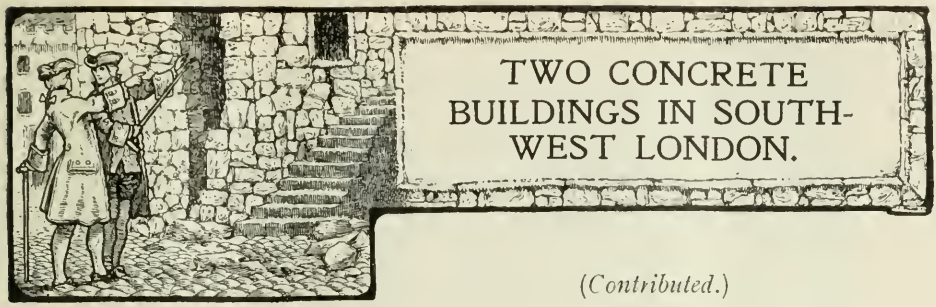
We are so frequently hearing examples proclaimed by advertising agents of concrete tanks being used for storage of corrosive liquids when so and so's speciality was an ingredient of the concrete, that we think special prominence ought to be given to a well-authenticated case of plain concrete being successfully used for storage of carbolic acid.

The tank in question was constructed by the Panama Canal Building Division, and had a working capacity of 12,000 gallons, being 25 ft. 10 in. × 11 ft. × 6 ft. 2 in. deep. The walls of the tank were 6 in. thick and were reinforced ; a steel float finish was applied to the interior surfaces. The concrete was a 1 : 1½ : 3 mix of sand and crushed gravel.

The carbolic acid that is stored in the tank is crude and contains not less than 15 per cent. of tar acids. After 2½ years' service it is stated that the appearance of the walls exposed to view is good, there is no loss of liquid through leakage, and the steel float finish is smooth and hard.

NOTICE TO SUBSCRIBERS.

The annual subscription to this magazine as from January 1, 1922, will be reduced to 18*s.* 9*d.* per annum, sample copies will be charged, as before, at 1*s.* 6*d.* each.



TWO CONCRETE BUILDINGS IN SOUTH-WEST LONDON.

(Contributed.)

THE two concrete buildings herewith described and illustrated have several features of interest, notably in the method of erecting the walling with a system of metal forms whereby considerable economy has been effected in the cost of shuttering and in the amount of labour and scaffolding required.

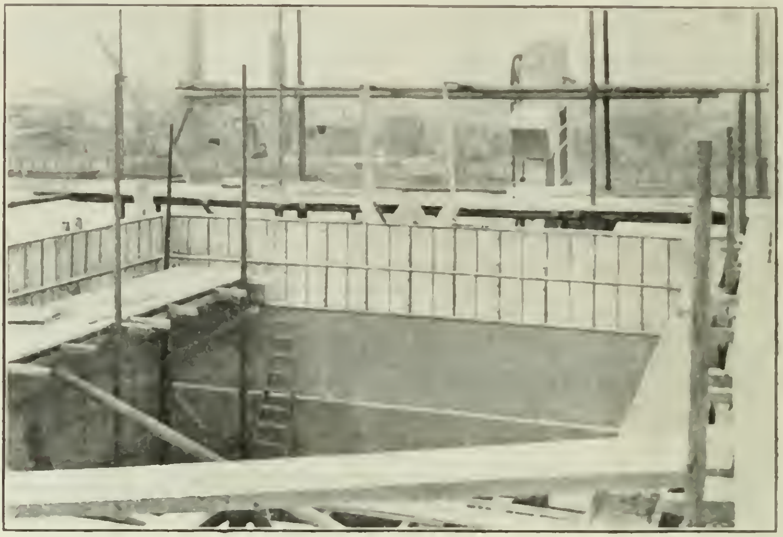
GRAIN STORE AT BATTERSEA.

The first building, of which Messrs. Trant Brown and Brightiff, of High Road, Kilburn, N.W. 6, are the architects, is being erected on the riverside at Battersea for Messrs. Garton, Sons & Co., and is known as Southampton Wharf. This firm has carried on the business of the manufacture of brewing sugars and corn syrup in Battersea for the past forty years, and now supplies the greater part of the requirements of the country in these products. The works as a whole occupy an area of about five acres, of which the building illustrated covers approximately three-quarters of an acre. It was originally proposed to carry out the work in brick, but owing to the war-time restrictions it was decided to use concrete as the constructional material. The same restrictions considerably hindered the progress of the work, but the building is now nearing completion. When completed, its main function will be the storage of materials used in the manufacture of corn syrup, and also the storage of the by-products of the business. Owing to the proximity of the river considerable site difficulties had to be overcome, and the foundations have been constructed on the raft principle with reinforced concrete on made-up ground.

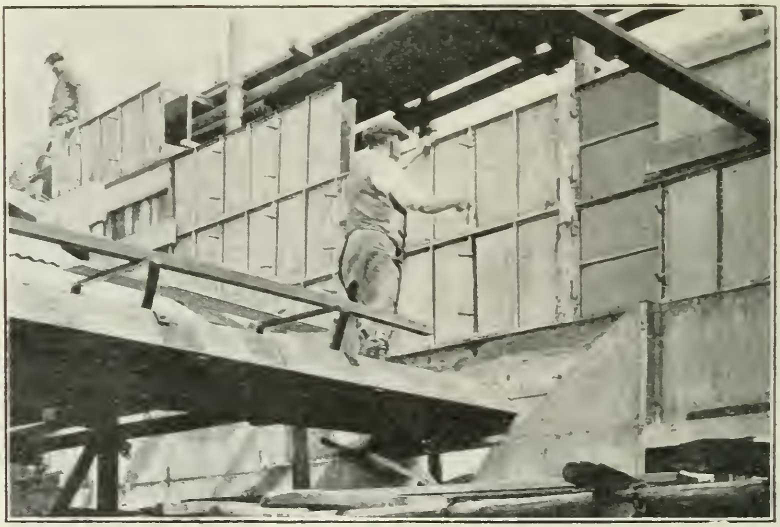
The main building is two stories in height, the first floor being supported by concrete pillars and beams. Perhaps the most interesting feature is the silos, of which there are ten, at the side of this building. These are built to hold 2,000 tons of maize, which raw material is unloaded from barges at the wharfside by an electric elevator by which it is conveyed first to the cleaning machines, from whence it is taken by a band conveyor to the silos. As required for use, the maize is conveyed by travelling bands from the silos to the different departments of the factory for conversion into corn syrup. The silos are 115 ft. by 27 ft. by 50 ft. in height, and are of reinforced concrete. The main building is of mass concrete, placed in position with the aid of metal forms. The reinforcement was supplied by the British Reinforced Concrete Engineering Co., Ltd., and the contractors for the whole of the work are Messrs. Holliday & Greenwood, Ltd., of Battersea.

PETROL DEPÔT AT WANDSWORTH.

The building now nearing completion for the British Petroleum Co., Ltd., is also situated on the riverside, at Point Pleasant, Wandsworth. The architects

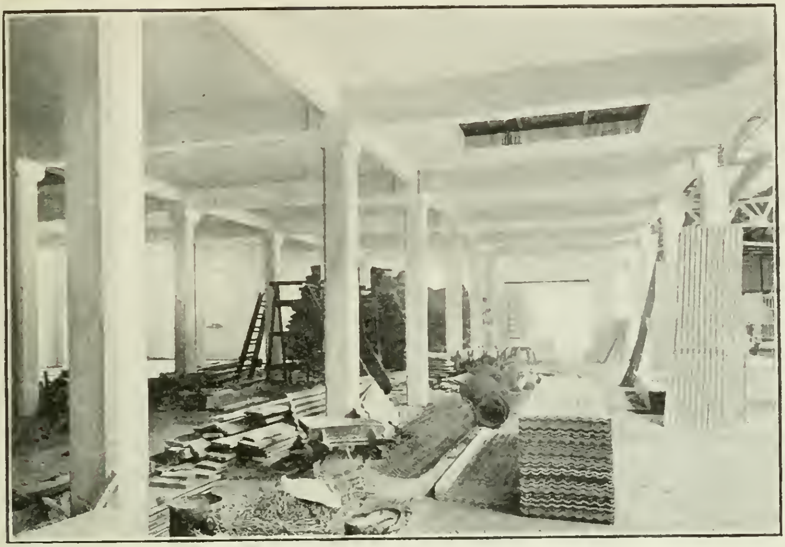


Silo during Construction.

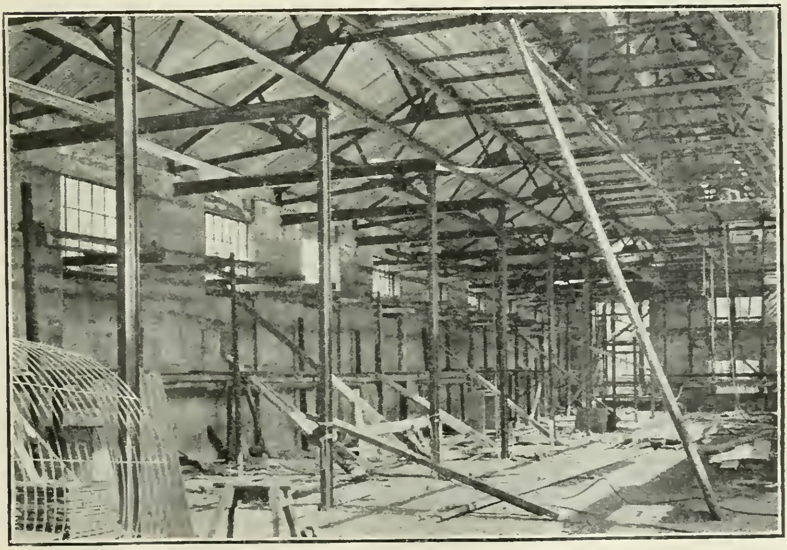


Showing Method of Shuttering.

GRAIN STORE AT BATTERSEA.



Ground Floor.



First Floor.

Grain Store at Battersea.

are Messrs. G. Pearson & Son, of Upper Thames Street, E.C., and the general contractors are Messrs. John Mowlem & Co., Ltd.

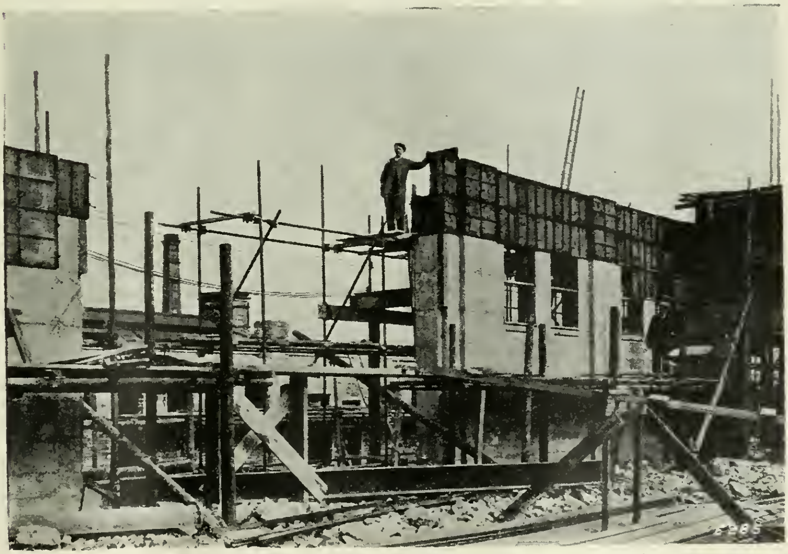
This building is to be used for the purpose of packing petrol, which will be delivered by water, and filling it into the familiar two-gallon cans for distribution. The main building is divided into three sections, the farthest from the river for receiving and cleaning the cans, the next section for painting them, and the section nearest the river is to be used for filling the cans with spirit. At the river end of this building are the storage tanks for the spirit, into which the spirit will be pumped direct from the barges. In this case, also, considerable difficulties were experienced with the site, which was originally an osier bed. To ensure a good foundation, piers 20 ft. long by 4 ft. diameter were sunk under the walls and surmounted by a reinforced concrete beam 2 ft. 6 in. wide by 2 ft. high, on which the walls rest. The building is one story in height, with the roof, which will be mainly glazed, supported on steel stanchions. Owing to the unstable nature of the soil on the site, the floor is made up of hard core topped with 6 in. of concrete with mesh reinforcement. In the construction of the floor an experiment was made with a mechanical tamper of the type made specially for tamping and consolidating the soil at the bottom of trenches. This machine has been used over the whole of the hard core with considerable success both from the points of view of satisfactory results and saving in labour—we were informed that the machine was performing the work of twenty men, and the blow of 3 cwt. ensured the thorough consolidation of the materials. The mass concrete walls of the building are being covered on the exterior with moulded concrete blocks.

The storage tanks are sunk below ground level and carried on a reinforced concrete raft 2 ft. thick.

Along the river frontage a reinforced concrete retaining wall is being constructed. This wall is 8 in. thick, and is carried 28 ft. above datum. The area behind it is to be filled in, and the sloping bank of the river thus levelled up and reclaimed.

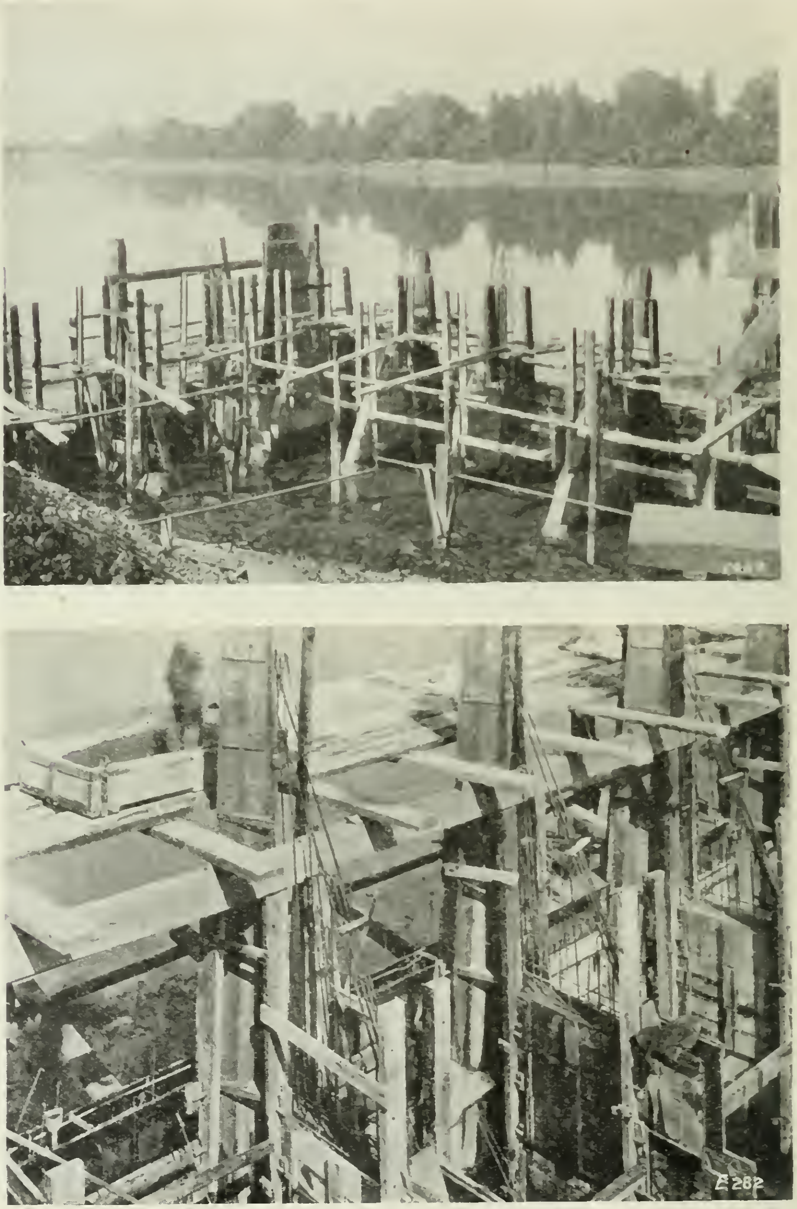
The whole of the concrete walling on this contract, including the retaining wall, and the walling to the main building and silos at Battersea are being constructed with " Metaforms," supplied by Messrs. A. A. Byrd & Co., of 50 Cannon Street, E.C. 4. Shuttering forms such a considerable proportion of the total cost of the construction of concrete buildings that any means by which it can be cheapened deserves the closest investigation, and there can be no doubt that the great waste of material and the labour entailed with wooden shuttering will ultimately lead to its replacement by something more durable and more simple in erection. On an average job at least 20 per cent. of the timber used for shuttering cannot be used again, and represents a dead loss ; in addition, there is the cost of the skilled labour required to cut it for each job and to erect and dismantle it, while the loss caused by the period during which actual building operations are delayed while the shuttering is being prepared and erected cannot always be estimated. The " Metaform " system used in the construction of these buildings is clearly shown in the illustrations. It consists of forms of 16-gauge sheet iron with a 1-in. by 1-in. mild steel angle round the edges and braced across the centre, and two stout clamps riveted to the right-hand vertical angle of each plate which by a simple upward movement securely locks each mould to its neighbour. The plates are made of a standard depth of 24 in. and in widths from 24 in. down to

2 in. Special forms are made for circular construction and for rounded and square corners, and with the use of these standard sizes any architectural design can be followed. Only sufficient forms are required to go three times round the building,



Petrol Depôt at Wandsworth: Main Building under Construction.

i.e., to a height of 6 ft. The method of operation is to place first the first course in position and fill in with concrete, after which a second and third course are erected and poured in like manner. The forms on the bottom course are then removed and placed in position above the third course to form the fourth course, and so on until the required height is reached. The size and weight of the forms are such that they are easily handled, and no heavy scaffolding is required. The system by which they are held in position while the concrete is being poured and while it is setting is extremely simple, but so effective that no



Petrol Depôt at Wandsworth: Retaining Wall.

bracing of any kind is required. They are held in position to form the desired thickness of walling by wires, which are cut and left in the wall when the forms are removed. To ensure the correct alignment of the wall, and also to prevent shearing of the plates, fixed dowel pins project from each outside vertical angle and fit into holes in the angle of the adjacent plates. There are no loose parts. On the two buildings illustrated herewith, on which we have seen them used, they are demonstrating their value as an aid to rapid and economical concrete construction. But the clean face left by metal forms has also to be considered, and for buildings of the warehouse class no plastering or other treatment is required where they are used. When the forms are removed the wall has the appearance of being built of blocks of smooth stone of the size of the forms used, and when distempered has quite an attractive appearance. A further advantage is claimed for this system in that the loss of cement is reduced to a minimum owing to the closeness with which the forms fit together when in position. In the case of the retaining wall at Wandsworth it is interesting to note that the whole of the work is being carried out without the use of coffer dams. The tide at this point rises some 14 ft., but owing to the use of the metal forms it was possible to allow the tide to cover each section as completed without any harmful results to the work.

Retaining Wall.

Petrol Depôt at Wandsworth.

WEST BANK DOCK ELECTRIC GENERATING STATION.

In a recent number of *The Engineer* a very interesting account appears of the new power station built for the United Alkali Company, Limited. The site of the Company's works is on the Mersey near the London and North-Western Railway bridge which spans the river between Widnes and Runcorn.

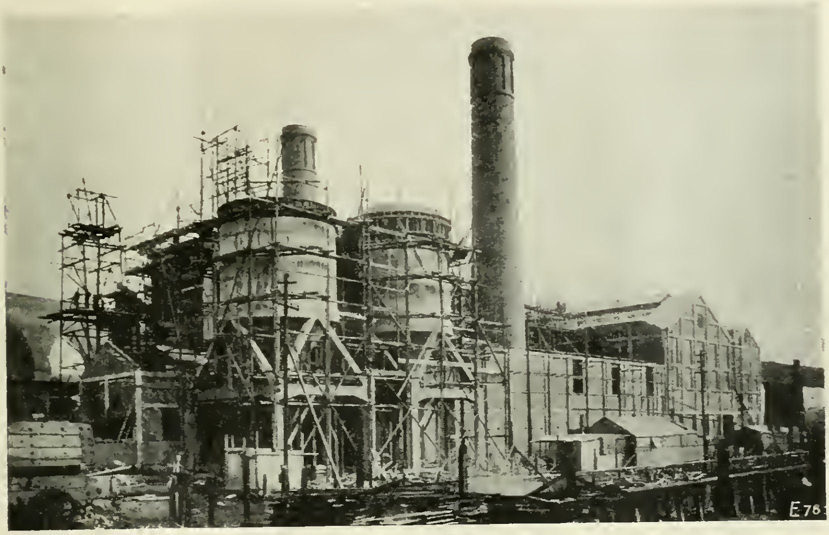
The station, when fully equipped, will be capable of supplying 20,000 Kilowatts.

Owing to the heavy loads which had to be carried, it was necessary to obtain a firm foundation on which to build the station. On one side, rock was found near the surface, but on the other side it was some distance down, and it was decided to pile where necessary with reinforced concrete piles 16in. diameter cast *in situ*. The manner in which these piles was produced is interesting and is as follows:—A heavy steel tube 16in. outside diameter was placed on the top of a loose cast-iron point and driven into the ground, by means of a heavy drop hammer operated by a high-speed friction winch, until the required final set was obtained. The tube was then filled with concrete to a height of several feet—according to the length of the pile—above the level at which it was desired to finish the head of the pile. A powerful lifting tackle was then coupled on and the tube was slowly and steadily pulled out of the ground, leaving the loose cast-iron point at the base of the pile. As the tube was withdrawn the concrete sank and expanded, filling up the hole so formed. Prior to depositing the concrete, the necessary reinforcement was placed inside the tube where necessary. The number of piles driven under the station was 741, and the approximate total length of piling was 15,000 ft., which gives an average length for each pile of 20 ft. Some of the piles, however, were as short as 11 ft., and others nearly 30 ft. long, and were reinforced with a 1-in. bar down the centre. The number of piles driven per week averaged thirty-five.

General View of Power Station during Construction.

The range of reinforced concrete coal bunkers extends the full length of the boiler-house. The bunkers are 28 ft. 6 in. wide, 25 ft. high, and are covered by the conveyor floor and housing. The total capacity of the bunkers is 900 tons. The crane beams in the turbine-house are also of reinforced concrete, and are supported on heavy concrete columns in the walls of the building, the columns in turn resting on the concrete piles. The crane spans the full width of the turbine-house, namely, 60 ft., and has a lifting capacity of 20 tons. In order to supply the necessary stability to the columns which support the crane beams, the former are tied into the floors on one side and into the bunker framework on the other. Owing to the soft nature of the ground, the basement floor under the firing floor is carried on concrete piles, and the necessary beams are provided to carry the heavy walls of the boiler settings. Large mass concrete piers support the boiler loads and the columns which carry the bunkers. An unusual feature in the boiler-house is the provision of a flue which extends the full length of the building, and is constructed entirely of reinforced concrete.

The boiler-house, engine-house, and switchgear annexe are in one block. The boiler-house consists of a reinforced concrete framework with brick panels. It is 160 ft. long by 115 ft. wide by 70 ft. high, the firing floor being 14 ft. above the basement level. The boiler-house will ultimately contain twelve boilers. The turbine-room is also a reinforced concrete building with brick panels.

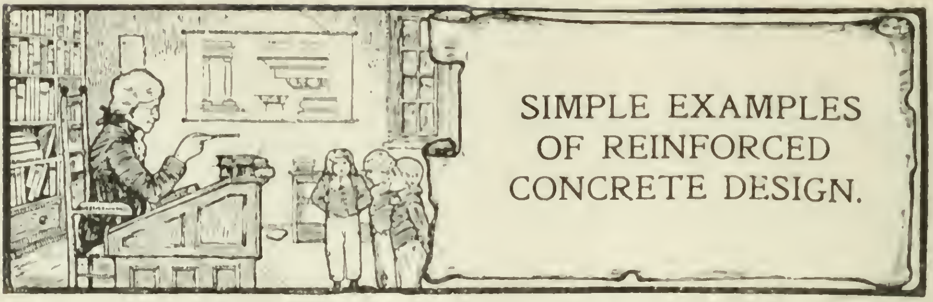


Buildings during Construction.

The ash receivers, which are of the usual double-cone type, are made of concrete, and supported above the railway siding by means of concrete legs. They measure about 20 ft. in diameter and 50 ft. in depth, the thickness of the cylindrical wall being about 5 in. Water for cooling the ashes is admitted through an elbow piece forming the air outlet, and at the top of the cylindrical portion rolled steel joists carry a very fine filter screen. Ash and air inlet nozzles are provided just below the screen, and the cone-shaped bottom is lined with renewable cast-iron plates and a discharge mouthpiece. Receivers of this kind are usually constructed of iron or steel plates, which are very liable to corrosion, owing to the presence of moisture and sulphur in the ashes, and it is anticipated that this source of trouble will be obviated by the use of concrete.

To deal with the water a pump-house has been erected on a site 200 ft. from the water intake and 330 ft. from the turbine-room. There are two reinforced concrete culverts, each 3 ft. diameter, connecting the river with the pump-house, the intakes being protected against damage from vessels by a heavy timber boom.

The whole of the work was carried out under the supervision of Mr. Holbrook Gaskell, M.I.E.E., A.M.I.Mech.E., at that time chief engineer to the United Alkali Company, Limited. The building work was carried out by the latter Company, the designs for the reinforced concrete work being supplied by the Indented Bar Company, the reinforced concrete piles on which the station is built being designed and supplied by Messrs. Stewarts.



SIMPLE EXAMPLES OF REINFORCED CONCRETE DESIGN.

By OSCAR FABER, O.B.E., D.Sc., etc.

(Continued.)

Example 2.

For our second example, we will take a small tank 10 ft. deep and 10 ft. square.

Design.—The distribution of water pressure against the sides will be exactly the same as explained in the first example, and therefore need not be reiterated.

The walls, in this case, being straight instead of circular will, however, be subject to bending as well as to tension.

Reverting back to Example 1, if we make a little model tank of flexible material to a square instead of a round design, and fill it with water, it will be found that it will distort at once, and will try to take up a circular form.

Such distortion in the case of a concrete tank would, of course, cause it to fracture, and the sides must be made capable of resisting this bending tendency without appreciable deflection.

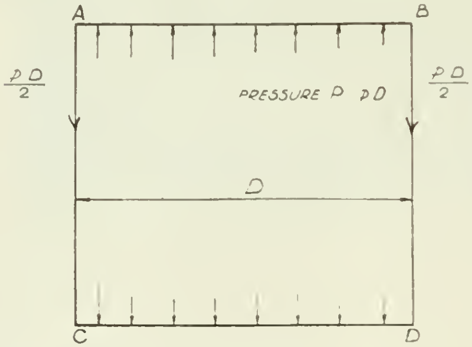


FIG 3

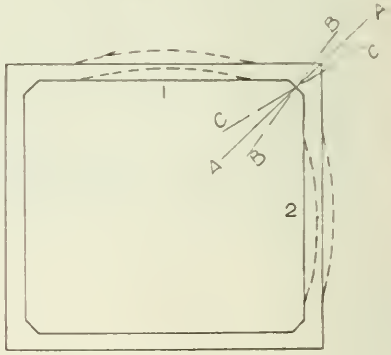


FIG 4

Referring to *Fig.* 3, and considering a horizontal section of wall 1 ft. high at any particular depth, the total pressure on one wall for this strip will clearly be

$$P = pD \text{ lb.}$$

where p = water pressure per square foot at that depth
D = diam. of tank in feet.

This pressure on the side AB is transmitted by the stiffness of the side to the two ends A and B, each end obviously having a reaction of

$$\frac{P}{2} = \frac{pD}{2}$$

which clearly represents a tension of that amount in the walls AC and BD, and balances the pressure in the opposite direction on the side CD.

Similarly pressure on the walls AC and BD produces bending in them and a tension of $\frac{pD}{2}$ in each of the walls AB and CD.

Each wall is therefore subject to a side pressure of pD and a tension of $\frac{pD}{2}$.

Now it was stated in *Reinforced Concrete Simply Explained* that continuous beams may be designed for a bending moment of

$$B = \frac{Wl}{12}$$

where W is the load or total pressure
l is the span, in our case, D.

Substituting, we have

$$B = \frac{pD \times D}{12} = \frac{pD^2}{12}$$

In the case of our example, the pressure increases uniformly with the depth, as explained in Example 1, but the lower portions of the sides receive support from the bottom.

The strip or section with the worst bending therefore occurs some little distance from the bottom, and may be taken at a height of three-tenths of the horizontal span.

This in our case is at a height of 3 ft. from the bottom, or at a depth of 7 ft. from the top.

Here the pressure is $7 \times 62\frac{1}{2} = 437$ lb. per sq. ft. and therefore the bending moment is

$$B = \frac{pD^2}{12} = \frac{437 \times 100}{12}$$
$$= 3{,}641\tfrac{2}{3} \text{ ft. lb.}$$
$$= 43{,}700 \text{ in. lb.}$$

Remembering that the resistance moment of a normally reinforced slab is

$$R = 95\ bd^2$$

where b = width of section = 12 in.
d = depth to the steel from the compressed edge

we may write

$$95\ bd^2 = 43{,}700 \text{ in. lbs.}$$
$$d = \sqrt{\frac{43{,}700}{95 \times 12}} = 6{\cdot}2 \text{ in.}$$

A 7 in. slab would therefore be sufficient.

The area of steel required is ·675 per cent. or

$$As = \frac{{\cdot}675}{100} \times 6{\cdot}2 \text{ in.} \times 12 \text{ in.} = {\cdot}5 \text{ sq. in.}$$

This area is required for a strip 12 in. wide, and is that required by considerations of bending only.

Reverting now to the direct tension in the sides of

$$T = \frac{pD}{2}$$

we have $p = 62\frac{1}{2} \times 7$ lb./ft.^{2}
$D = 10$ ft.

$$\text{whence } T = \frac{62\frac{1}{2} \times 7 \times 10}{2} = 2{,}180 \text{ lb.}$$

This tension may be considered as acting uniformly across the slab, half of it as adding to the tension to be carried by the steel, on one side of the slab, the other half as reducing the total compression on the concrete on the other side.*

---

* This does not pretend to be *strictly* accurate, though quite near enough. The accurate treatment of combined bending in tension is given in *Reinforced Concrete Design*, Vol. I.

The additional steel required to carry this additional tension is therefore

$$As = \frac{1,000}{16,000} = \cdot 07 \text{ sq. in.}$$

Hence the total area of steel required is

$$As = \cdot 5 + \cdot 07 = \cdot 57 \text{ sq. in.}$$

Now 3—½ in. rods give this area, and therefore ½-in. rods at 4-in. centres are required.

As regards the thickness of 7 in., it should be noted that had the required thickness come to less than 6 in., as for example in the case of a smaller tank of the same depth, we should still have required to make it at least 6 in. so as to achieve water-tightness, in accordance with the minimum thicknesses from this consideration recommended in Example 1.

A word of explanation is needed, perhaps, in regard to having treated the sides as continuous beams. A little consideration will show that a beam (of which a section of our slab is a special case) is no less continuous because it happens to be bent or cranked at the support.

The distribution of bending moment as between end and support, which is approximately met by designing for $\frac{Wl}{12}$ in both places, corresponds to conditions when the beam is partially fixed in direction at its end.

This was hardly touched on in *Reinforced Concrete Simply Explained*, but is fully gone into in *Reinforced Concrete Design*, Vols. I and II.

In the case of our square tank, the conditions are really better than this, and are, as far as fixity of the corners in direction is concerned, those of beams *fully fixed* in direction at their ends.

This is obvious from symmetry.

Consider one of the corners in *Fig.* 4. It is clear that the line AA, with the tank empty, would remain in exactly the same direction after the tank was filled, because although the deflection of the side 1 would tend to make AA turn towards the direction CC, the equal deflection of the side 2 would equally tend to make it turn towards the direction BB, and the net result would be to leave it where it was.

Now, any book on elementary theory of structures will show that a beam having its ends *perfectly* fixed in direction has a bending moment of $-\frac{Wl}{12}$ at the ends and $+\frac{Wl}{24}$ at the centre.

It may therefore appear that in designing for $+\frac{Wl}{12}$ at the centre, we have designed wastefully.

There is, however, another consideration affecting this, as follows :—

It has been shown (for example, in *Reinforced Concrete Design*, Vol. I) that a beam sharply bent is much weaker at the kink or bend than a straight beam of similar dimensions.

Partly for this reason, and also partly because of the high adhesion stresses at the corner, and of the greater difficulty in placing the rods in exactly the right position in the corners, it is unsafe, at any rate in small tanks, to rely entirely on the full fixity at the corners, and therefore the design for $+\frac{Wl}{12}$ at midspan is a prudent precaution.

Coming now to the question of stresses, it will be recalled that the formula

$$R = 95\ bd^2$$

which we used, was based on stresses of 600 lb./in.^{2} in the concrete and 16,000 lb./in.^{2} in the steel, and it will be remembered that in Example 1, a stress limitation of 8,000 lb./in.^{2} in the steel was recommended for watertightness. Some explanation of this apparent anomaly is clearly desirable, and is as follows.

In Example 1 (a circular tank) the walls were shown to be in pure tension. In this case, the tendency to crack the concrete would extend uniformly through the wall, and any cracks would probably also so extend, leaving a clear passage for leakage.

In Example 2, where the walls are subject to bending stresses, the tension exists on one side only, the opposite side being in compression. Hence in this construction, the cracks are not likely to extend beyond the neutral axis, the effect of the compression on the other side being rather to close up any incipient cracks, and hence higher stresses are safe as regards watertightness.

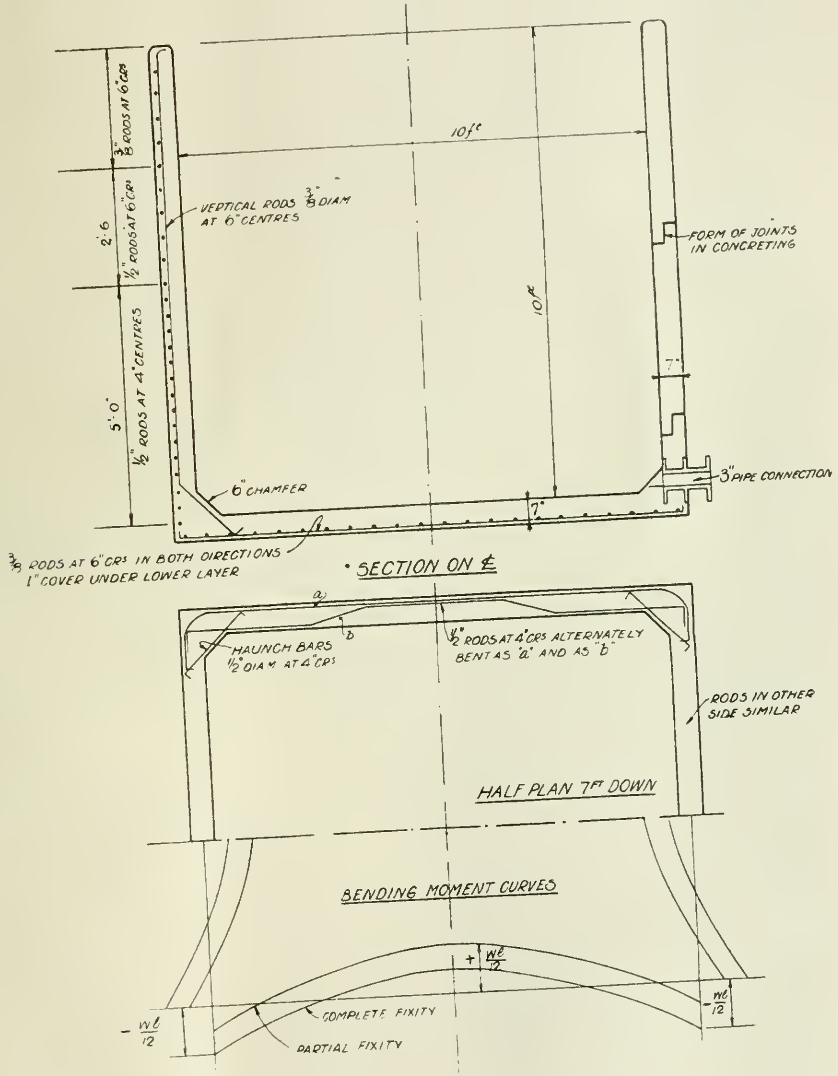


FIG 5

SQUARE CONCRETE TANK

Only near the point of contraflexure (the point separating the negative bending moment at the ends from the positive moment near the centre) is there tension right across the section, and here the stresses are quite small.

This point is generally distant about one-fifth of the span from the ends, and in our case, the tension there is

$$T = 2{,}180 \text{ lb. per ft. wide section and the area of steel}$$
$$As = \cdot 57 \text{ sq. in. per ft}$$

whence the stress is

$$t = \frac{2180}{\cdot 57} = 3830 \text{ lb./in.}^2,$$

well within our limiting stress of 8,000 lb./in.^{2} for pure tension.

In the design, *Fig.* 5, it will be noticed that the internal corners are made less sharp by a haunch or chamfer. The object of this is to overcome to some extent the dangers and disadvantages of sharply bent beams previously referred to.

As regards the bottom, resting directly on the earth, this may be 6 in. thick reinforced with $\frac{3}{8}$ in. rods at 6 in. centres in both directions.

The sides have so far been designed for the worst point, which occurs about 7 ft. down. Clearly the pressure is proportionately less above this point. In our small tank, it is hardly worth while reducing the wall thickness higher up owing to the complication to the centering or timber mould, but the steel may be proportionately spaced out above this point as indicated.

As regards materials, rendering, joints, etc., the remarks in Example 1 apply.

In *Fig.* 5, the bending moment curves are given, both for perfect fixity at the ends, and for partial fixity, and the actual curve lies at some point between the two. But in our design we have prudently designed for the worst moment in either curve.

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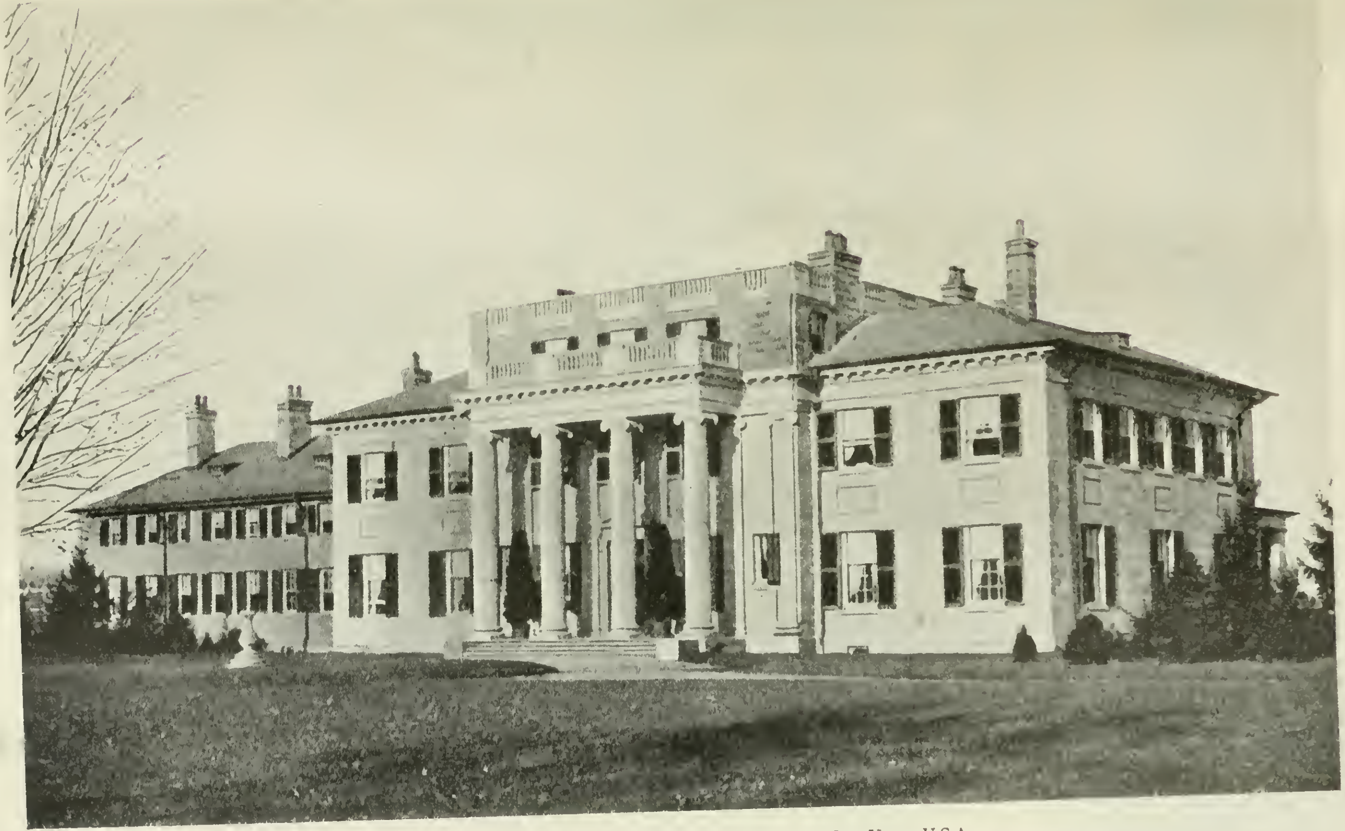
AMERICAN DOMESTIC ARCHITECTURE.

THE block is probably the most general form for the use of concrete in England for domestic purposes, and during the last few years many thousands of small houses have been constructed by means of the concrete block. There has been a great diversity in the type of block used, but, for the most part, no advantage has been found to accrue by departure from the simple rectangular shape, in which form the construction is generally but the substitution of a concrete block for a stone one. In America, however, the exploitation of the concrete block has been carried to lengths unknown in England, and this method has been employed for the construction of houses of considerable magnitude, as may be seen by the accompanying illustration.

The simple dignified classical treatment is particularly suitable to a block construction, for most of the walls on the main block are simple ashlaring with sunk panels between the ground and first floor windows. There is an excellent balance between the large central mass and the subsidiary flanking portions, and the central feature is given a right emphasis by the large projection of the entablature carried on four ionic columns. The whole design is suggestive of a rural Palladianism, the unusual note being given by the presence of the louvred shutters. The proportion between the various members of the entablature is not altogether satisfactory, the cornice lacking dignity on account of a certain paltriness and inadequate bed-moulding, as a result of which a very poor shadow is cast. The strong framing emphasis of a deep shadow would have improved the whole composition.

Attention has been given to all the details, and without doubt care has been expended in the selection of the aggregate, so as to obtain a surface good in both colour and texture. The whole building is interesting in that it indicates the vast possibilities of concrete block construction, and should give confidence to English architects who may imagine that the concrete block is only suited to a humble type of dwelling.



A LARGE CONCRETE BLOCK HOUSE AT PORT CHESTER, NEW YORK, U.S.A.
[*Architects: Messrs. Carrere & Hastings, Blake & Butler.*

SECONDARY STRESSES IN MONOLITHIC STRUCTURES AND HOW TO CALCULATE THEM.

By **R. J. HARRINGTON HUDSON**, B.Eng., A.M.I.C.E., A.M.I.Mech.E., M.C.I.,
M.Am.C.I., Executive Engineer, Public Works, India.

Continued from p. 718.

THE investigations of stresses are based on the following particular generalised form of the equations of the Theorem of Three Moments, applied to any two spans *A–B*, *B–C*, of a continuous beam (*Fig.* 3), the inertia moments of which need not be the same in the two spans.*

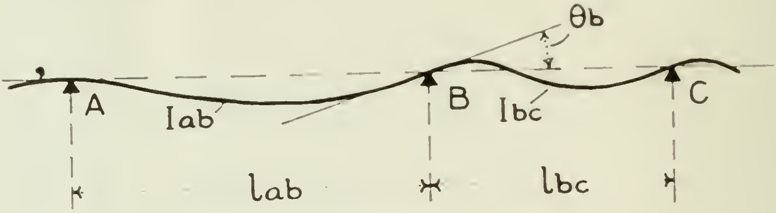


FIG.3.

$$-E\cdot Ibc\cdot \tan\theta b = \tfrac{1}{6}\,Bc\cdot lbc + \tfrac{1}{3}\,Bb\cdot lbc + \tfrac{1}{2}\,Qbc\cdot lbc \qquad \text{I}$$

$$E\cdot Iab\cdot \tan\theta b = \tfrac{1}{6}\,Ba\cdot lab + \tfrac{1}{3}\,Bb\cdot lab + \tfrac{1}{2}\,Qab\cdot lab \qquad \text{II}$$

where *E* = *elastic* modulus of the structural material.
Iab, *Ibc* = *inertia* moments of the beam in spans *A–B*, *B–C*.
θb = the angle which the tangent to the beam at support *B* makes with the horizontal.
Ba, *Bb*... = the *bending* moments in the beam at supports *A*, *B*,...
lab, *lbc* = the *lengths* of spans *A–B*, *B–C*.
Qab, *Qbc* = *qualifiers* which depend upon the distribution of weight on the spans *A–B*, *B–C*, and have the values set down in Table, I, where W_1, W_2 denote the total weights on the spans *AB*, *BC* respectively.

The distributions of weight (1), (2) and (3), Table I, are those most commonly met with in practice.

It will be observed that, when the spans are equal (Table I, column 3), *lab* = *lbc* = *l*.

When equations I and II are both applied to one and the same span then, provided the weight is distributed symmetrically on the span, *Qab* = *Qbc* = *Q*.

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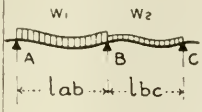
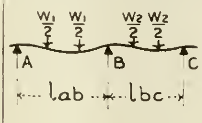
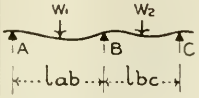
* For proof of these equations the reader should consult Appendix I (4) of Handbook refered to in footnote, page 789.

TABLE I

COL 1		COL 2		COL 3	
FIGURE 4	DISTRIBUTION OF WEIGHT	SPANS UNEQUAL		SPANS EQUAL	
		Qab	Qbc	Qab	Qbc
	(1) WEIGHT UNIFORMLY DISTRIBUTED	$\frac{1}{12}W_1 \cdot lab$	$\frac{1}{12}W_2 \cdot lbc$	$\frac{1}{12}W_1 \cdot l$	$\frac{1}{12}W_2 \cdot l$
	(2) WEIGHT AT THIRD POINTS	$\frac{1}{9}W_1 \cdot lab$	$\frac{1}{9}W_2 \cdot lbc$	$\frac{1}{9}W_1 \cdot l$	$\frac{1}{9}W_2 \cdot l$
	(3) WEIGHT AT CENTRE	$\frac{1}{8}W_1 \cdot lab$	$\frac{1}{8}W_2 \cdot lbc$	$\frac{1}{8}W_1 \cdot l$	$\frac{1}{8}W_2 \cdot l$

Consider a beam b–c of single span l monolithic with two pillars a–b, d–c, height h. *Fig.* 5. The beam loaded with any distribution of weight (1), (2) or (3), *vide* Table I, and *Fig.* 4.

Ib = *inertia* moment of *beam.*

Ip = *inertia* moment of *pillars* which are fixed in direction at their bases, a and d.

Bending moments only will be investigated and the pillars may be relieved from the vertical reactions Rb, Rc, by supporting the ends of the beam as shown in *Fig.* 5.

Bending moments are transmitted from the beam to the pillars through rigid right-angled connections at b and c. Provided the connections are rigid * the angle is

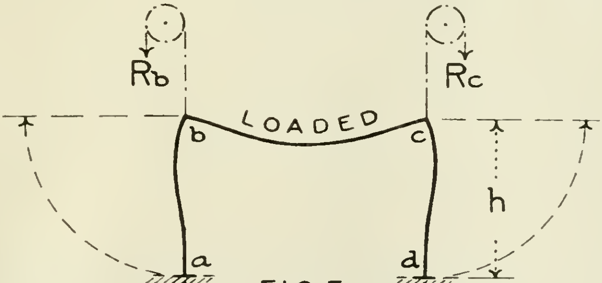


FIG.5.

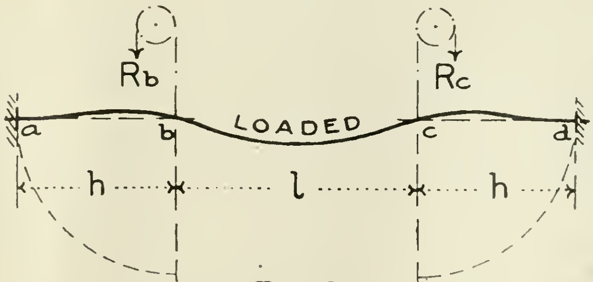


FIG.6.

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* See foot-note, page 716, November issue.

of no consequence and, for convenience, the pillars may each be rotated outwards through a right angle bringing them into line with, and still rigidly connected with, the beam, *vide Fig.* 6.

The bases *a*, *d*, of the pillars are now fixed in a horizontal direction and the system takes the form of a continuous beam of three spans with ends fixed horizontally (*Fig.* 6). The middle span only is loaded, and as the system is symmetrical only the middle span and one outer span need be considered.

Take span *c–d*, which represents pillar *c–d* in *Fig.* 5 There is no transverse weight on the pillars, so the qualifier Q is zero.

Applying equation I—

$$-E\cdot Ip\cdot\tan\theta c = \tfrac{1}{6}\,Bd\cdot h + \tfrac{1}{3}\,Bc\cdot h \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Applying equation II to the same span—

$$E\cdot Ip\cdot\tan\theta d = \tfrac{1}{6}\,Bc\cdot h + \tfrac{1}{3}\,Bd\cdot h$$

but $\theta d = 0$ as the end d is fixed horizontally

$$\therefore\ 0 = \tfrac{1}{6}\,Bc\cdot h + \tfrac{1}{3}\,Bd\cdot h$$

$$Bd = -\tfrac{1}{2}\,Bc \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Consider span *b–c*.

Applying equation II—

$$E\cdot Ib\cdot\tan\theta c = \tfrac{1}{6}\,Bb\cdot l + \tfrac{1}{3}\,Bc\cdot l + \tfrac{1}{2}\,Q\cdot l \quad . \quad . \quad . \quad . \quad . \quad (3)$$

From (1) $\quad -E\cdot\tan\theta c = (1/Ip)(\tfrac{1}{6}\,Bd\cdot h + \tfrac{1}{3}\,Bc\cdot h) \quad . \quad . \quad . \quad . \quad (4)$

From (3) $\quad E\cdot\tan\theta c = (1/Ib)(\tfrac{1}{6}\,Bb\cdot l + \tfrac{1}{3}\,Bc\cdot l + \tfrac{1}{2}\,Q\cdot l) \quad . \quad . \quad . \quad (5)$

Adding (4) and (5)

$$(1/Ib)(\tfrac{1}{6}\,Bb\cdot l + \tfrac{1}{3}\,Bc\cdot l + \tfrac{1}{2}\,Q\cdot l) + (1/Ip)(\tfrac{1}{6}\,Bd\cdot h + \tfrac{1}{3}\,Bc\cdot h) = 0$$

but $Bb = Bc$ by symmetry, and it was proved in (2) that $Bd = -\tfrac{1}{2}\,Bc$,

$$\therefore\ (1/Ib)(\tfrac{1}{2}\,Bc\cdot l + \tfrac{1}{2}\,Q\cdot l) + (1/Ip)(-\tfrac{1}{12}\,Bc\cdot h + \tfrac{1}{3}\,Bc\cdot h) = 0$$

$$Bc[(l/2Ib) - (h/12Ip) + (h/3Ip)] = -(1/Ib)(\tfrac{1}{2}\,Q\cdot l)$$

$$Bc = -\left[\frac{12Ib\cdot Ip\cdot l}{6Ib^2\cdot h + 12Ib\cdot Ip\cdot l}\right]Q$$

$$= -\left[\frac{2}{(Ib/Ip)(h/l) + 2}\right]Q$$

Substituting $ri = Ib/Ip$, $rl = l/h$ and noting that $Bb = Bc$

$$Bb = Bc = -\left[\frac{2}{(ri/rl) + 2}\right]Q \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$Bb = Bc = -Fa\cdot Q \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6a)$$

where Fa represents the expression within square brackets.

Now imagine the spans *a–b* and *d–c*, *Fig.* 6 (which represent pillars *a–b* and *d–c*, *Fig.* 5), to be gradually decreased in length by moving supports *a* and *d* with their horizontal fixing up to supports *b* and *c* respectively until $h \longrightarrow 0$ and the ratio $l/h \longrightarrow \infty$. Ultimately, when $h = 0$ and the ratio $l/h = \infty$, supports *a* and *d* have coincided with supports *b* and *c* and the horizontal fixing has applied itself to the ends *b* and *c* of the beam (*Fig.* 7).

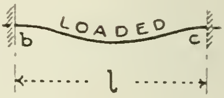

FIG. 7.

Substituting $h = 0$ or $rl = l/h = \infty$ in equation (6) the expression in square brackets represented by Fa in equation (6*a*), reduces to— $\quad 2/2 = 1$

and therefore—

$$Bb = Bc = -Q.$$

In other words, in the case of a beam of single span supported on monolithic pillars fixed in direction at their bases, the value of the qualifier Q represents the negative moment at the ends of the beam when the ends are fixed horizontally. Conversely, *the value of the qualifier Q may be found by calculating the negative moment at the ends of a similar fixed beam.*

It is immaterial whether the weight on the beam is distributed symmetrically or unsymmetrically. Take, for example, a weight W at any point on the beam, distant x from b and x' from c, *vide Fig.* 8.

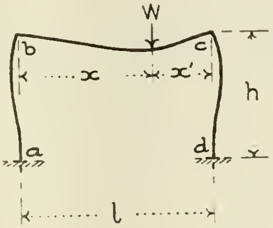

FIG.8.

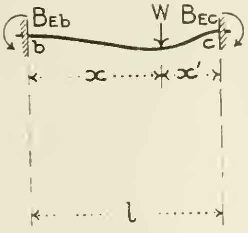

FIG.9.

When $h = o$ or the ratio $rl = l/h = \infty$ the beam is fixed horizontally at the ends (Fig. 9). The negative moments at the ends of this fixed beam may be written down at once, viz.—

$$B_{E}b = -\frac{W \cdot x \cdot x'^2}{l^2} = -Qb,$$

$$B_{E}c = -\frac{W \cdot x^2 \cdot x'}{l^2} = -Qc,$$

where Qb and Qc are the *qualifiers* to be used in the equation for the bending moment at b and c respectively in *Fig.* 8, therefore—

$$Bb = -\left[\frac{2}{(ri/rl) + 2}\right] \cdot \frac{W \cdot x \cdot x'^2}{l^2}$$

$$Bc = -\left[\frac{2}{(ri/rl) + 2}\right] \frac{W \cdot x^2 \cdot x'}{l^2}$$

The relations of Ba to Bb and of Bd to Bc, expressed in equation (2), viz.—

$$Ba = -\tfrac{1}{2}\ Bb$$
$$Bd = -\tfrac{1}{2}\ Bc$$

are true in all cases where the pillars are fixed in direction at their bases, but

$$Bb = Bc$$

only when the weight is distributed *symmetrically* on the beam.

Referring to equation (6) it will be observed that the value of the expression within square brackets, represented by Fa in equation (6*a*), depends solely upon the value of the *ratio of ratios* (ri/rl). It has therefore been possible to construct a very simple Alignment Chart, Chart No. I.A. (*Fig.* 11), to enable the value of the expression in square brackets, represented on scale Fa of the Chart, to be read off for all ordinary values of Ib, Ip, l and h. The maximum bending moments in the pillars are then given by the simple formulae—

$$Bb = Fa \cdot Qb,$$
$$Bc = Fa \cdot Qc,$$

where Qb, Qc are obtained from a consideration of the negative bending moments at the ends of a similar *fixed* beam.

When the weight is distributed symmetrically on the beam, then—

$$Qb = Qc = Q \text{ and}$$
$$Bb = Bc = Fa \cdot Q$$

Values of Q for three of the most common symmetrical distributions of weight on a beam are given in Table I, page 785.

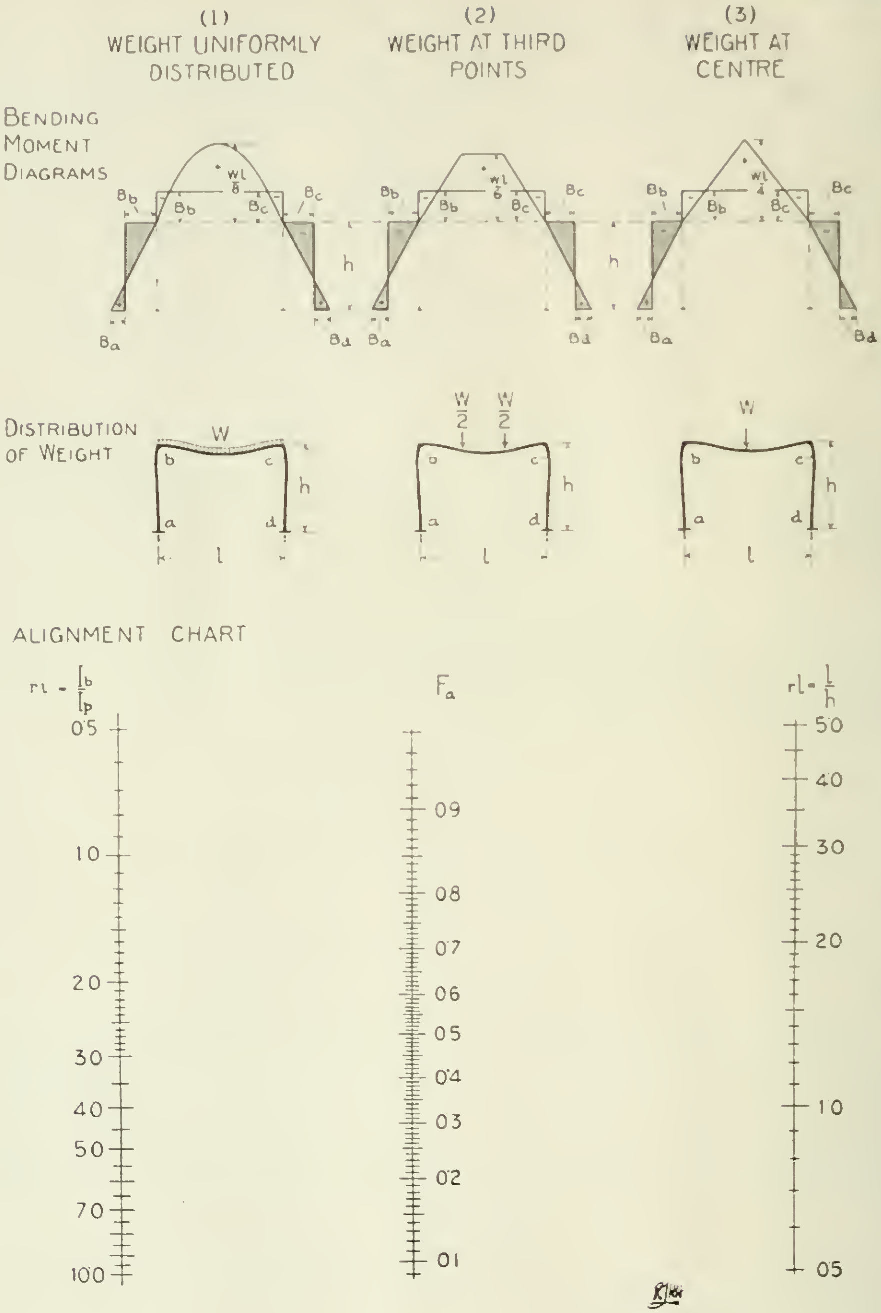

Fig. 11.

This Chart No. I A is the first of a series of five charts named Type A (single span), the scope of which is indicated on the sketch (*Fig.* 12).

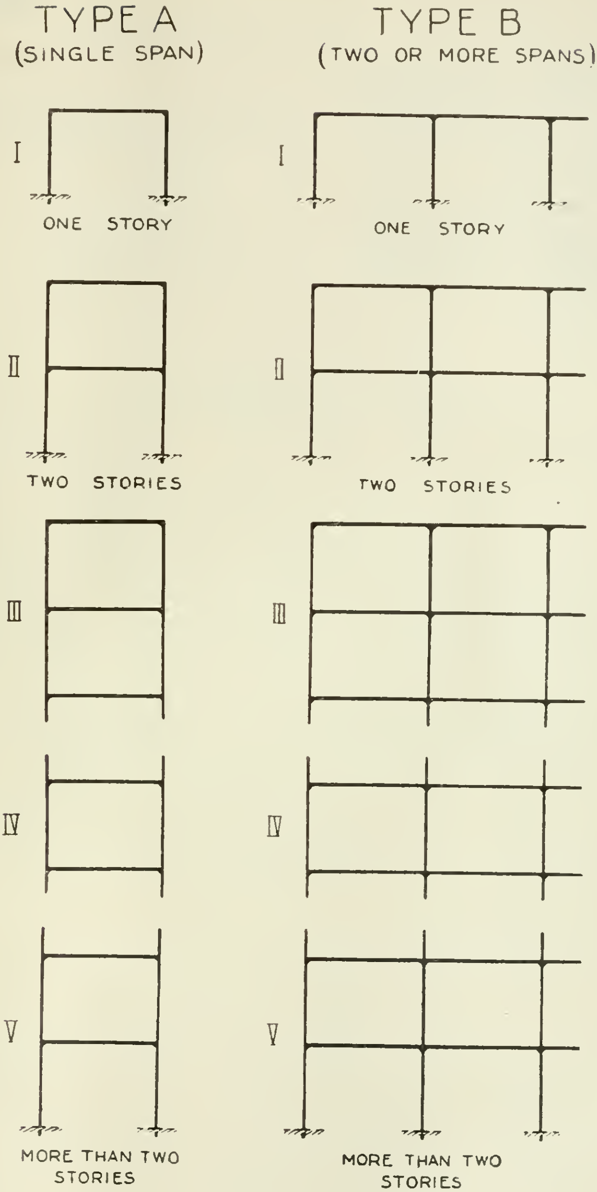

FIG. 12.

Space only permits of the proof and reproduction of one of the charts, Chart No. I A being selected for the purpose of illustrating the system. Type B refers to two or more spans with any distribution of dead and superimposed weight on the spans.*

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* This article must necessarily be brief and only a very small portion of the field open to investigation by the writer's method can be covered. For a full treatment with Charts the reader should consult Chapter X and Appendices II, III and IV of *Reinforced Concrete: A Practical Handbook*, by R. J. Harrington Hudson, shortly to be published by Chapman & Hall.

THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

THE ANNUAL DINNER.

In accordance with the wish and example of H.M. the King, and owing to the prevailing unemployment, the Annual Dinner has been postponed until the Spring of 1922.

Early notification of the date to be fixed will be afforded to all members

THE TRANSACTIONS.

The Council have decided to publish the *Transactions and Notes* periodically during the Session, instead of annually as hitherto; and it is hoped that Number 1 of Volume XII, containing the Presidential Address delivered in November 1921 and other matter, will be published early in January 1922. These periodical issues will contain the proceedings at General Meetings, etc., and other matters of interest to members; and correspondence from members on topics of general interest will be published from time to time as space may permit.

Correspondence which members desire to have published should be addressed to the Editor, The Concrete Institute Transactions, 296, Vauxhall Bridge Road, S.W.1.

Members who prefer to receive the *Transactions and Notes* annually as hitherto should communicate with the Secretary at once; otherwise they will be supplied with the periodical issues as these are published.

Binding cases and an Index for the periodical issues will be available as each Volume comes to a conclusion.

Volumes X and XI will remain in abeyance for the moment but will, it is hoped, be published shortly to complete the series to date.

THE YEAR BOOK OF THE INSTITUTE.

The Council have decided, in place of the "List of Members" published hitherto (last issued in 1919) to publish annually a *Year Book*, which will contain, besides the list of members, all important matter relating to the Concrete Institute and its activities, other than matter published in the *Transactions*.

The first issue will be published on Monday, April 10th, 1922 (the day before the Building Exhibition opens at Olympia).

THE LIBRARY.

Members are cordially invited to present books, either technical or non-technical, dealing with concrete, reinforced concrete, and engineering generally, to the Library.

Authors and publishers presenting books to the Library may have them reviewed in the periodical *Transactions* when space permits, if they desire it.

It is hoped to commence publication of a catalogue of the books in the Library as soon as possible in the periodical *Transactions*, which will afterwards be collated and issued separately.

NEW MEMBERS OF THE INSTITUTE.

A total of 69 new members, comprising 40 Members, 24 Associate-Members, 1 Associate, 1 Licentiate, and 3 Graduates, were elected at the General Meeting of the Institute held on November 24th, 1921. Their names and addresses will be published in the *Transactions* in due course.

CONCRETE AGGREGATES—*continued.*

Note.—The publication of these lists commenced in the August issue, 1920, and was continued in the issues for September, November, December, 1920, and in March, April, May, June, July, August and September of the present year.

The Concrete Institute takes no responsibility for the accuracy of the information supplied.

For footnote references, see September, 1920, issue.

Leckhampton (Gloucestershire).

General Description : Concrete aggregates.
Source and locality of same : The Leckhampton Quarries (Co., Ltd.).
How obtained : Quarrying.
From whom obtained : The Leckhampton Quarries Co., Ltd.
Is available quantity limited? No.
Present maximum output per day in cubic yards : 200.
Transport facilities : Tractor, Rail or horse haulage. Station : Cheltenham South (G.W.R.).
Is there any provision at or near source for washing or crushing ? Yes.
Price per cubic yard, and where delivered : Prices given to contractors.
Is composition uniform ? Yes.
Detailed description :—
- (*i*) *Kind of stone or coarse material :* "Calsonyx," Lotswold Dale.
- (*ii*) *Kind of sand or fine material :* "Calsonyx" fine clean sharp sand.
- (*iii*) *Relative proportions of coarse and fine material :* As desired.
- (*iv*) *Shape of particles :* Angular.
- (*v*) *Impurities present :* None. 98 per cent. pure carbonate.

Weight per cub. foot, dry : 16 cub. feet to ton.
Proportion of voids : According to proportions.
Crushing strength of stone : 7,132 lb. per square end equals 458·6 tons per square foot.

Ledbury (Hereford).

General description } Ledbury Quarry, ½-mile east of Ledbury
Source and locality } Town, on the Tewkesbury Road.
How obtained : From Wenlock limestone-bed.
From whom obtained : Ledbury R.D.C. (Surveyor's Dept.).
Is available quantity limited ? At present to 30 cub. yds. per day.
Transport facilities: Traction engine and 4-ton lorry constantly employed by the Council.
Is there any provision at or near source for washing or crushing ? Yes, for crushing and screening ; washing unnecessary.
Price per cub. yard, and where delivered : 8s. per yard. In quarry, all sizes.
Is composition uniform ? Yes.
Detailed description :—
- (*i*) *Kind of stone or coarse material :* Large rough building stone.
- (*ii*) *Kind of sand or fine material :* 5 in., 2½ in., 2 in., 1½ in., ¾ in., ⅜ in., sand.
- (*iii*) *Relative proportions of coarse and fine material :* From bin screens as desired.
- (*iv*) *Shape of particles :* Angular.
- (*v*) *Size of particles :* As desired.
- (*vi*) *Impurities present :* Nil.

PRESIDENTIAL ADDRESS.

The opening meeting of the Institute's Session was held on Thursday, November 24, when Mr. E. Fiander Etchells, F.R.I.B.A., delivered his Presidential Address.

In his opening remarks Mr. Etchells said that, although there had been an enormous development in concrete work during the past few years, little provision had been made for systematic education in concrete theory and practice.

What was wanted was a new type of mechanic, the expert concretor and block setter. Up to now, the education of the concretor had been left very largely to chance; it was true that technical institutions included concrete as part of their engineering courses, but that was only incidental. It was imperative that provision should be made for training young men, in the interests of the future of the industry, and it might be done through the various technical schools and institutes throughout the country. In the curriculum of these institutions, concrete should be regarded as an independent subject. The details of the scheme would have to be worked out by a committee, and he suggested that a small committee of the Concrete Institute should be appointed to draw up a suggestive course on modern lines to be submitted to the authorities. The object of these educational courses would be to produce skilled concretors and block setters who, by passing an examination and gaining a certificate, would have a definite status in the industry which was already in existence but which had yet to be organised. The examinations might be carried out by the Concrete Institute which already had the necessary machinery for holding such examinations, but the classes would be held at the various technical schools. Allied with this was the question of a concretors' union. It could hardly be put forward from the masters' side that such a union should be formed, in order to give such men a definite status in the industry. Such an organisation was, however, desirable, and it might be the means of absorbing some of the men at present unemployed and without any special trade, and of training them. Thus a body of skilled workers would be available to deal with concrete work and they would be enabled to work alongside the other trades in the building industry. The Institute could hardly put forward the suggestion, neither could the employers, but he threw it out for what it was worth, hoping that the artisans, or some of them, would take up the case and found a union of their own.

The Address then went on to deal with a number of technical questions which Mr. Etchells thought might be of interest to members.

BRICKWORK.

Discussing the strength of brickwork, Mr. Etchells said that one dominant factor was the necessity for making allowance for the psychology of the bricklayer, the plumber and the electrician, who frequently quite indifferently cut away piers after the loads had been carefully calculated and reduced the whole strength of the structure. With regard to the strength of brick pillars in themselves, one or two laws stood out from the weltering chaos of data; for example, tests showed that: (*a*) The crushing strength of individual bricks may be five to ten times the crushing strength of the piers as a whole. (*b*) For any given quality of mortar, the strength of the pier varies with the strength of the individual bricks in the pier. (*c*) For any given quality of bricks the strength of the pier varies with the strength of the mortar. (*d*) If a mortar comprised of one volume of Portland cement and four volumes of sand be used in lieu of mortar comprised of one volume of freshly burned lime and two volumes of sand, the crushing resistance of the pier will be increased by an amount which may reach 25 tons per sq. ft. For example, a pier in lime mortar which might crush at 25 tons per sq. ft., might be expected to resist 50 tons if cement mortar were used as specified above. (*e*) If blue bricks or other hard bricks are to be used, it is desirable that a rich cement mortar should also be used, in order that some advantage might be obtained from the hard bricks. On the other hand, if very soft bricks are used, the pier will be strengthened by the use of cement mortar instead of lime. (*f*) There is something beyond a simple crushing resistance involved in the failure of brickwork. There is tensile stress on the bulging side of a brick pier. There is also a question of adhesion between the mortar and the brickwork. Many piers fail by splitting longitudinally and the use of cement mortar is more efficacious in reducing the splitting tendency. (*g*) Since lime mortar sets by the absorption of carbon dioxide from the atmosphere, and since the outer coating of mortar sets first, and tends to protect the inner lime from atmospheric influences, it not infrequently happens that the lime mortar in the interior of a thick pier dries up rather than sets. An examination of the interior of brick piers which have failed appear to indicate that in some instances the mortar had never acted as a true cement material. (*h*) In order to increase adhesion of the mortar to the bricks, it is essential that the bricks, if absorbent, should be well soaked before being used, and should be well drenched after being laid, otherwise there is a great risk of the bricks absorbing the moisture from the mortar and thus retarding or hindering the setting. Some of these facts should be clear to designers, but an examination of piers which had failed disclosed that "somebody forgot."

Dealing with the thickness of walls, it was pointed out that in most areas of the United Kingdom, the thickness of walls is governed by the local Building Acts or by-laws, but in cases where there is no such guidance the following formula would be found useful :—

$$n = \tfrac{1}{2} + \frac{H}{40}\ \text{ft.} + \frac{L}{90}\ \text{ft.}$$

where n is the number of the bricks in the thickness at the base of the walls ; H is the height of the wall in feet and L is the length of the wall in feet. This rule might be applied to factory chimneys, domestic buildings and factories.

As to pressure on foundations, some textbooks gave permissible pressure of brick piers having a height not exceeding twelve times the least diameter of the pier, and such books did not permit any greater pressure in the case of brick foundations in which height is only a fraction of the width of the base. In such cases it would appear quite reasonable to allow a bearing pressure 25 per cent. in excess of the average compressive stress on such a slender pier as that referred to. At the same time, Mr. Etchells said he did not overlook the fact that in many cases the size of the brickwork is determined more by the bearing resistance of the earth below the foundation than by the pressure superimposed upon the brickwork.

R.I.B.A. Report on Reinforced Concrete.

In the ten years which have elapsed since the R.I.B.A. published their second report, continued the Address, much additional data has been obtained. Ten years ago, in the endeavour to seek generality in the pillar formulæ, and to devise a rule which would enable Mouchel and Considère pillars to be brought to the same standard of comparison, it was recommended that only the concrete within the hooped core, or lateral binding, should be considered as load-bearing material. It was also considered that the concrete outside the binding would flake off long before the ultimate load is reached. At a later stage, it began to be realised that a large percentage of pillars were eccentrically loaded and were, in consequence, liable to flexure and the concrete outside the binding would, in some cases, undoubtedly be in compression. Some of these facts were foreseen at an early stage, but as there was at that time prejudice in some directions against any calculations of the fact of eccentricity, it was felt that the difficulty could be partly met by allowing only the area of the core to be considered as constituting the compression area of the pillar, and to allow the concrete outside the laterals on one side of the pillar to be useful in resisting the flexural stresses due to the eccentricity of the load. At a later stage, when the prejudice against calculations for eccentricity of loading had somewhat subsided, it was recognised that it would be unreasonable not to allow all the concrete in the pillar to be considered as a part of the pillar, particularly if the question of flexural stresses was under consideration. It was felt, for the time being, at any rate, that the member was, in effect, a vertical beam subject to direct compression in addition to the flexural stresses. In the meantime, two students of reinforced concrete, Dr. Faber in England and Captain Harrington Hudson in India, were engaged on the laborious calculations necessary to find the general formulae which would take into account a series of pillars with the beam over them as constituting in itself one truly monolithic structure subject to deflections. The result of Dr. Faber's work was published first, but Captain Hudson's work was quite independent. Dr. Faber obtained his results by considering the slope of the elastic line at every part of the beam. His calculation involved the use of a stiffness factor which is the heterogeneous rate subsisting between the inertia moment and the length of the member. Captain Hudson obtained his results by an ingenious abduction of the theorem of three moments and he uses two pure ratios which are obtained, in the first case, by using the pure ratio between the inertia moment of the pillar, and in the second case, finding the pure ratio between the length of the beam and the height of the pillar. The results were in close agreement, and if it were not for the introduction of one or two subsidiary, though inevitable, arbitrary factors, the agreement would be complete. There was no doubt at all that those who had to formulate rules for monolithic construction must hereafter take into account the work of these two engineers. It was possible, however, that for some time to come there would be engineers who would prefer to design their structures on the assumption that all loads are central, and all beams freely supported, and afterwards recognising that their assumptions are not in accordance with fact, they will add an arbitrary amount of steel to minimise the tendency to cracking.

Finally, the question of standard notation was referred to and it was pointed out that the standard notation of the Concrete Institute would be found in two forthcoming books by Dr. Faber and Captain Harrington Hudson respectively.

DON'TS FOR CONCRETE.

The following is taken from a Paper recently read by Mr. S. Bylander before the Liverpool Architectural Association :—

Sometimes in practical work it is most valuable to look at those things which should be guarded against. Here are a few suggestions "What not to Do."

(1) Don't do any concrete without complete detail drawings and written instructions as the design of R.C. work is too intricate to be determined on the site.

(2) Don't do any concrete without instructions regarding approved proportions and kind of cement and approved aggregate and approved construction joints. The R.C. drawings should give requirements for each part of the structures.

(3) Don't do any concreting of a part until the reinforcement is secured in position accurate to drawings and approved for that part.

(4) Don't use cement of unknown and unapproved quality. Keep each lot of cement separate on site in sheds till test results are known.

(5) Don't use sand which is dirty and contains more than 3 per cent. in volume of very fine materials (loam or clay) settling in water on top of the sand in a measuring glass after shaking with water, nor if dark in colour indicating organic matters, nor sand having majority grains less than $\frac{1}{32}$ unless mortar test is approved.

(6) Don't use coarse materials mixed with sand, or if dirty (surface coated with clay, etc.), or if not graded and of proper size, or if containing excess of stone dust, or if soft and not of specified kind.

(7) Don't proportion coarse material and sand or cement without the use of reliable measuring devices such as boxes, hoppers, bags, scales, etc. The component parts must be measured separately; apportioning by judgment without measure may be dangerous.

(8) Don't allow excessive amount of sand or water in the mix. Measure correctly every mix.

(9) Don't forget to keep mixer clean. Gravel and water does it.

(10) Don't re-mix or use partly set concrete.

(*Continued on page* 829.)

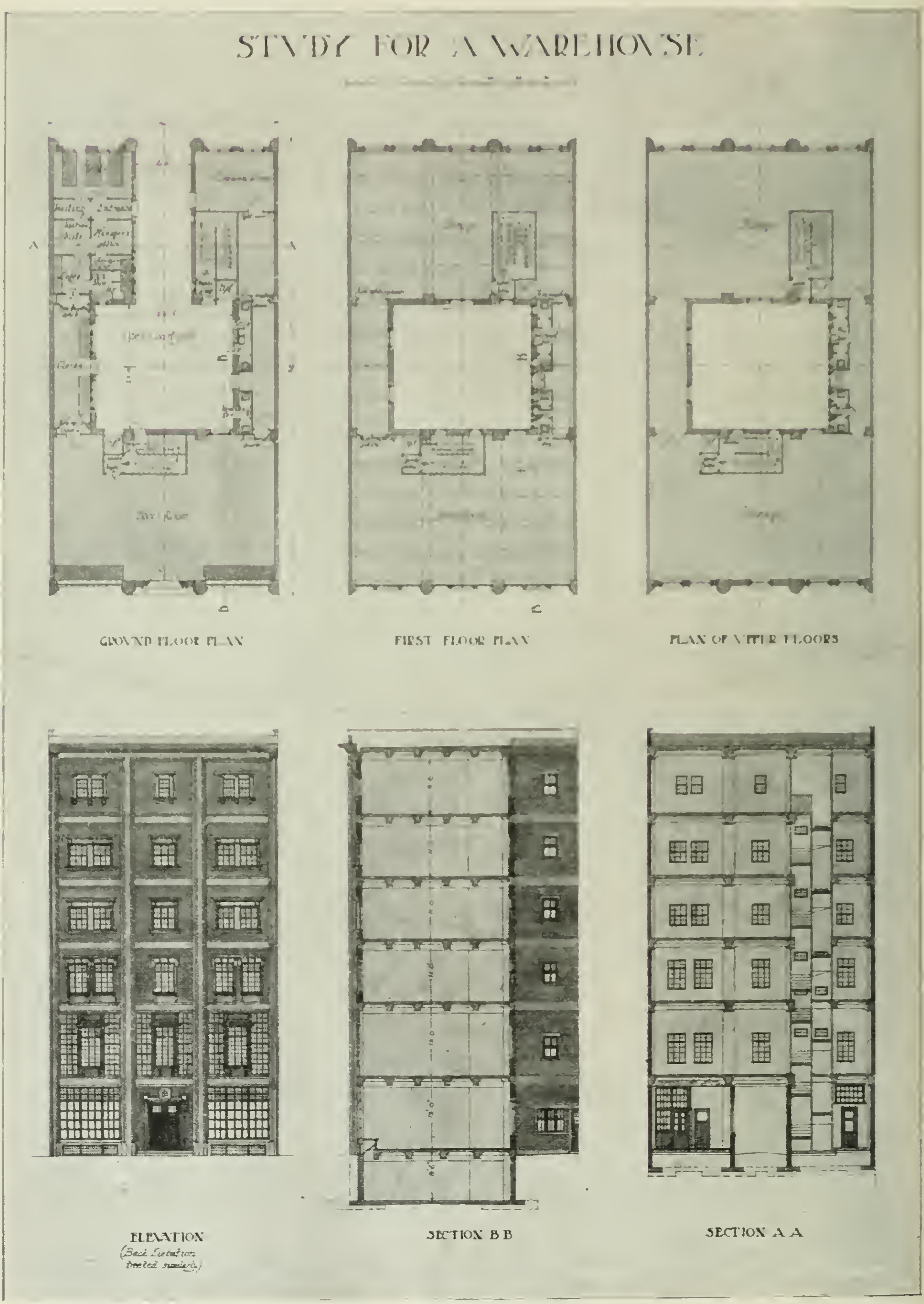
STUDY FOR A WAREHOUSE

In response to our invitation to Students and others to submit to us designs for structures in concrete with a view to their publication in these pages, we have received the drawings which we reproduce herewith ; the work of a student who modestly desires to remain anonymous. We hope that this may be the first of a series, the interest of which will, we feel sure, not be restricted to students.

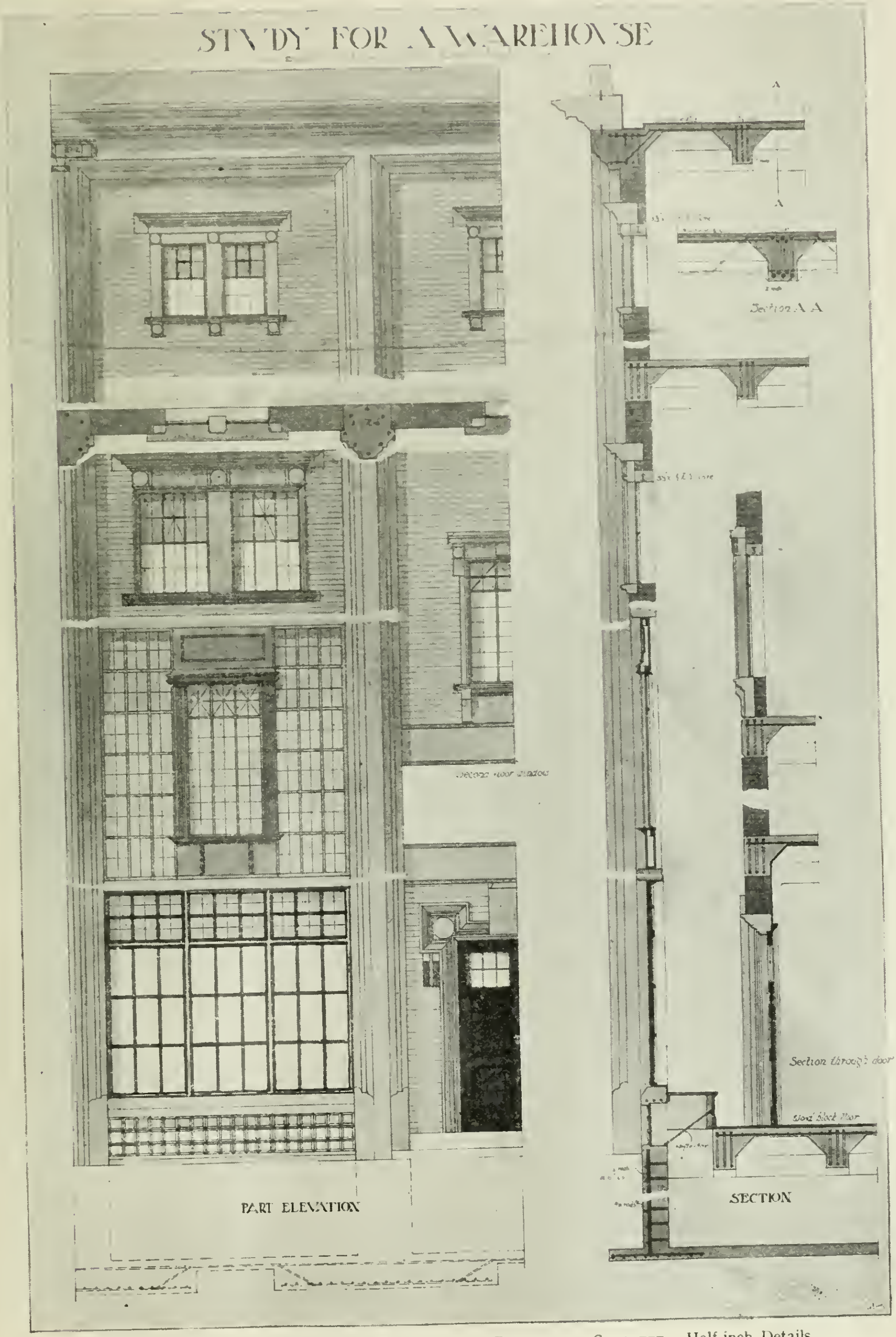
In submitting this work to us, its author wrote : " The problem was to design a warehouse in reinforced concrete on a rectangular site which was flanked by buildings on the wider sides, and had its narrow sides fronting roads. The accommodation was to include show-rooms and storage, and room for a manager's office and small clerical staff. My main idea in designing the elevation was to emphasise the structural members by making them form an integral part in the decorative treatment."

This is, in our opinion, the only sound method of approaching the problem, and the result achieved, with all its defects, is more satisfactory than would have been the clothing of a reinforced concrete structure with dead and unrelated forms. The continuously moulded vertical piers are reminiscent of certain modern German shop architecture, where they form a very clever solution to the problem of providing a large expanse of glass area. The returning of this moulding along the underside of a top beam, thus framing the building into three panels, is effective, logical, and, we think, original ; and the subsidiary horizontal bands formed by the floors are both structurally and æsthetically sound. The less satisfactory features in the elevation occur where other materials than concrete are employed. The cornice, for instance, is insignificant, and a more harmonious result would, we think, have been obtained by the use of a bolder but simpler moulded member executed also in reinforced concrete. There would appear to be no reason why the curtain walls should be in brick and not in concrete block, but an even better arrangement would have been to have omitted these entirely and continued, with a slight modification, the arrangement on the first floor ; by this means additional light would have been obtained, and the whole composition would undoubtedly have benefited. There is too great an assortment of window treatment, yet none varies sufficiently to form a contrast or give an emphasis, and, for the most part, the bed-moulding of the window cornices is excessive. The details of the main door are coarse, yet the design lacks boldness. These, however, are matters which would be rectified by maturer experience. The main lines of the composition are, we think, distinctly good, and the work displays that boldness and freshness of attack which is essential for the proper exploitation of a new material.

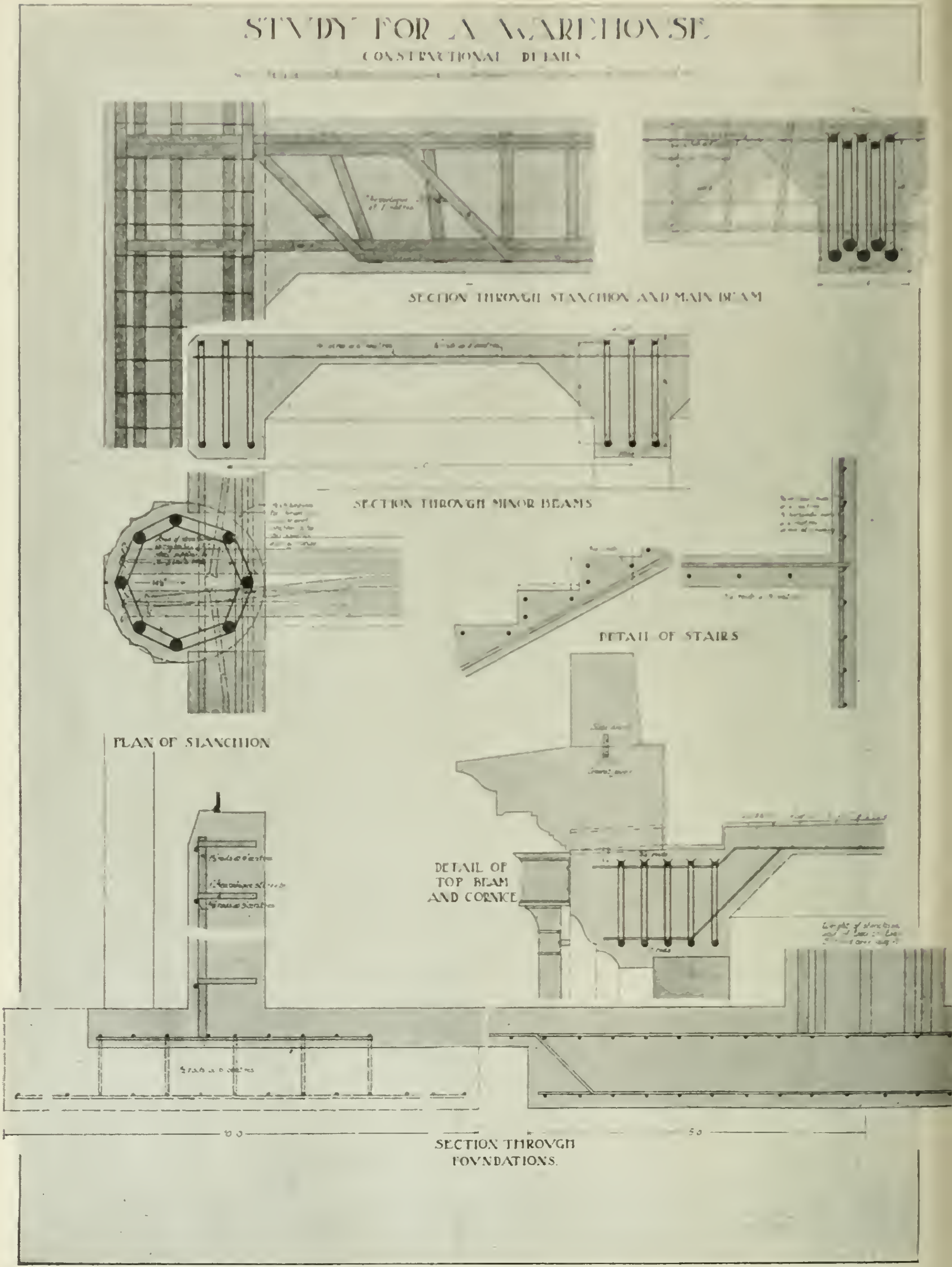
The planning is simple and straightforward, and the constructional details are well considered.



Students' Work.—Design for a Warehouse in Reinforced Concrete.



STUDENTS' WORK.—DESIGN FOR A WAREHOUSE IN REINFORCED CONCRETE. Half-inch Details.


STUDY FOR A WAREHOUSE
CONSTRUCTIONAL DETAILS
SECTION THROUGH STANCHION AND MAIN BEAM
SECTION THROUGH MINOR BEAMS
PLAN OF STANCHION
DETAIL OF STAIRS
DETAIL OF TOP BEAM AND CORNICE
SECTION THROUGH FOUNDATIONS

STUDENTS' WORK.—DESIGN FOR A WAREHOUSE IN REINFORCED CONCRETE. Constructional Details.

THE FIRE RESISTANCE OF CONCRETE AND REINFORCED CONCRETE.

The following (abstract continued from page 727 of our November issue) is from a paper read by Mr. D. W. Wood before the Junior Institution of Engineers, and summarises the details and results of tests carried out by the British Fire Prevention Committee with the aid of grants made by the Scientific and Industrial Research Department. Our illustrations are reproduced from the Red Books of the British Fire Prevention Committee dealing with these tests, and we are indebted to the Controller of H.M. Stationery Office for his permission to make use of these photographs.—Ed.

(*Continued from p. 727.*)

RESULTS OF AND LESSONS FROM THE TESTS ON REINFORCED CONCRETE.

In addition to those ascertained from the tests with the plain concrete slabs the following points are worthy of attention.

Sizing.—The pre-determined maximum of ¾ in. was found to be the best size, as larger pieces did not allow the concrete to hug the reinforcement as closely as is essential.

Cover.—That is the amount of concrete below the lower layer of reinforcement.

Of the sixty-two slabs, five had ½ in. cover and all collapsed during the tests (R.C. 3, 3x, 5, 6, 8); nine had ½ in. and in addition some form of "protection," such as concrete composed of coke breeze, pan breeze, or broken brick (R.C. 11, 11x, 12, 12x, 22, 26, 26x, 37, 38), and three of these collapsed during the test (R.C. 12, 37, 38); forty-three had 1 in. cover and fifteen of these failed, whilst four had 1½ in. cover with no failures (R.C. 4, 4x, 27, 27 R.), and one had 2 in. cover, which collapsed (R.C. 14). These results clearly indicate that the absolute minimum of cover in the case of flat slabs should be at least 1 in. and not ½ in. as set forth in the R.I.B.A. Report on Reinforced Concrete.

"*Protection.*"—This idea did not prove to be of any real advantage, the nine slabs not proving satisfactory, except in the case of two slabs of a year old (R.C. 11x, 12x).

Aggregates.—The *natural* aggregates will be dealt with first, of which there were thirty-four slabs. As with the plain concretes the gravel aggregates, of which there were sixteen slabs, did not give satisfactory results, and no other conclusion can be reached than that concrete made of this material should be altogether avoided. The sandstones also proved unsatisfactory, whilst the limestones did a little better. Of the igneous rocks, three collapsed, and with two exceptions those that survived the fire tests had very serious permanent deflections ranging from 5 in. to 9½ in. The two exceptions were Nottingham basalt (R.C. 17) and trachyte (R.C. 19). See also slab R.C. 42.

Of the twenty-eight slabs composed of *artificial* aggregates the four slabs made of pan breeze were unsuccessful, and of the six slabs of coke breeze three collapsed during the tests and the other three had permanent deflections of 3½ in. 4 in. and 7¼ in. Slag made a poor show with a deflection of 6⅝ in., and of the three clinkers one with sand as the "fine" aggregate collapsed, and the others had deflections of 2½ and 3 in.

As with the plain concrete slabs, those made of brick proved on the whole the most successful. There were ten tests, of which two collapsed—one with ½ in. cover and the other in which fine coke breeze was used in place of sand. A rather noticeable feature was the case of two one-year-old slabs. The original R.C. 11, with ½ in. cover and 1 in. coke breeze protection had a deflection of 9¾ in., whilst its twelve-month-old companion (R.C. 11x) only had 1¼ in. deflection. R.C. 24 when nearly four months old gave such good results of only 2 in. deflection that it was repaired and re-tested with a further deflection of only ½ in., but the twelve-month old slab had a deflection of 5¼ in. (R.C. 24x).

From Red Book 224.

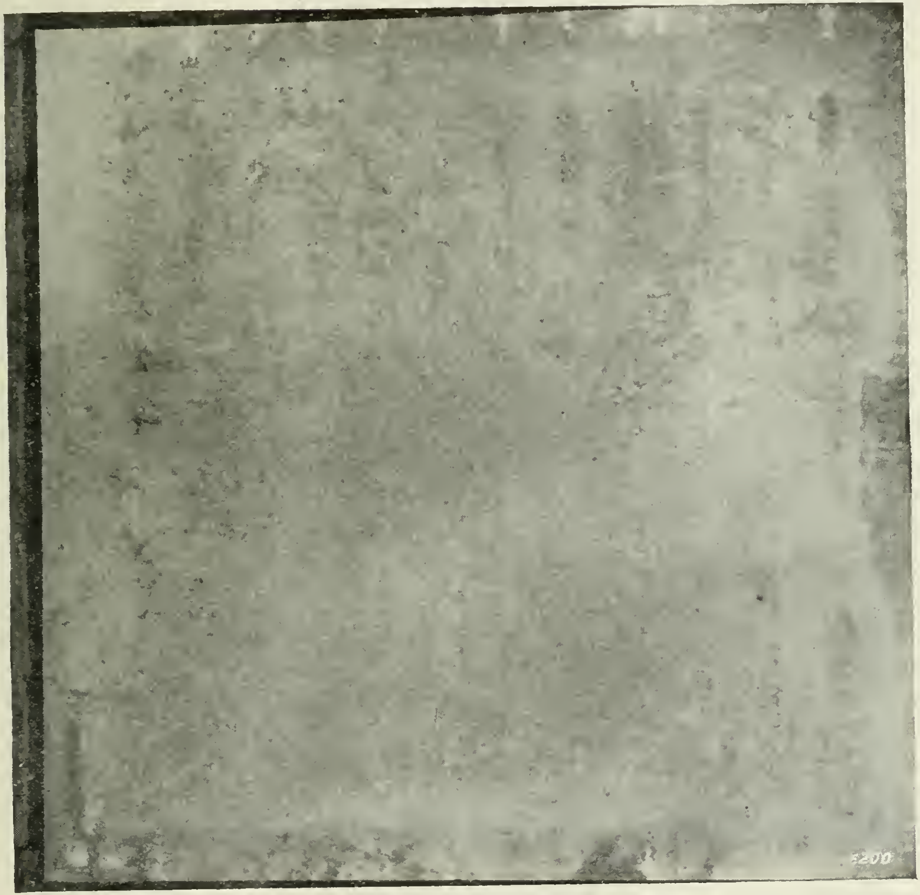
PLAIN CONCRETE SLAB THAMES BALLAST, 4; SAND, 2; CEMENT, 1.
Slab fell after 193 minutes of test. Maximum temperature 1870° F.

Gault clay when mixed with its own fine stuff gave thoroughly good results as follows, but the two slabs in which sand was employed collapsed (R.C. 33, 44). The first test with gault clay and its own fine stuff (R.C. 34) only had a deflection of 1½ in., that it was repaired and re-tested when a further deflection of 1⅛ in. was manifest (R.C. 34, R.).

This gives a total of twenty-four slabs collapsing, half being of natural aggregates and the others of artificial aggregates, viz. :—five of Thames ballast, seven other natural aggregates, four of pan breeze, three coke breeze, one clinker, two of broken brick and two of gault clay.

Of the sixty-three slabs four were repaired and re-tested as has been mentioned; nine had "protection" concrete and thirteen were twelve months old. It is interesting to compare the results of these last with the similar slabs but about three months old :—

Thames ballast	R.C. 3 collapsed	193 min.	R.C. 3x collapsed	220 min.
,,	4 deflection	9 in.	4x deflection	10½ in.
,,	7 deflection	11⅝ in.	7x deflection	15½ in.
,, (C.B. protn.)	12 collapsed	234 min.	12x deflection	2¾ in.
,,	26 deflection	9¼ in.	26x deflection	5¼ in.
Limestone (Buxton)	25 deflection	7¼ in.	25x deflection	4 in.
Trachyte	19 deflection	2⅞ in.	19x deflection	3¾ in.
Shap granite	23 collapsed	198 min.	23x deflection	7⅞ in.
Pan breeze	15 collapsed	155 min.	15x collapsed	122 min.



From Red Book 232.

Reinforced Concrete Slab R.C. 24. Broken Brick (from Brickworks), 4; Sand, 2; Cement, 1. Permanent deflection in centre after test, 2 inches. Top of slab after test and after removal of load.

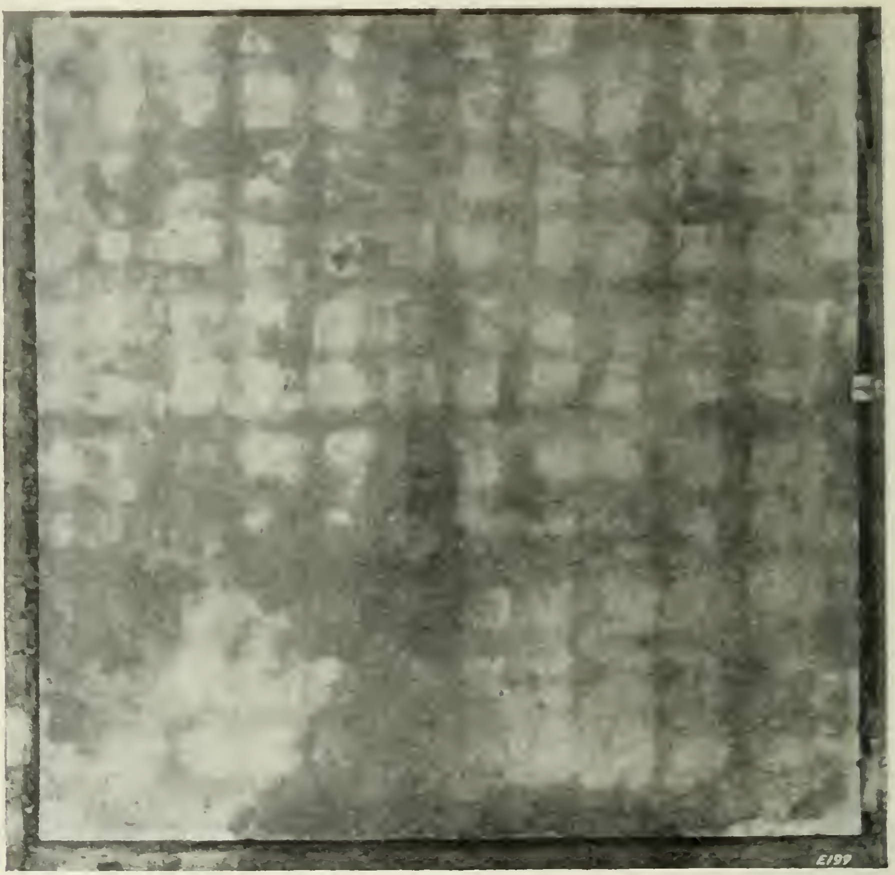
Coke breeze (2. 3. 1.)	13 deflection	3½ in.	13x collapsed	230 min.
,,	16 deflection	7¼ in.	16x deflection	4 in.
Broken brick (C.B. protn.)	11 deflection	9¼ in.	11x deflection	1¼ in.
,, (sand, 4. 2. 1.)	24 deflection	2 in.	24x deflection	5¼ in.

From this table it will be seen that nine pairs gave fairly similar results, but of the other four pairs two of the year old slabs (R.C. 11x and 12x) proved more satisfactory than the greener ones, and two less satisfactory (R.C. 13x and 24x), thus tending to support the theory that twelve months' seasoning improves the fire resistance by eliminating the latent moisture which it is assumed is converted into steam and causes the detachment of the "protection," as R.C. 11 and 12 both had coke breeze protection to the $\frac{1}{2}$ in. cover.

A remarkable feature of the tests was the regularity of the formation of the cracks and consequently the form assumed by those slabs which collapsed.

The cracks mostly went diagonally across the corners, frequently forming a complete diamond and in others hexagonal and octagonal shapes. This would seem to prove Bach's theory, that diagonal reinforcement is necessary. Had opportunity offered it was proposed to have made some tests in this direction.

With regard to the failures it should be pointed out that as regards the reinforcement the working stress—16,000 lb. per sq. in.—to which it is generally subjected, becomes the breaking stress at about 1,200°F. If only $\frac{1}{2}$ in. cover is provided it has been ascertained by the conductivity tests on a number of concretes comprised of very similar aggregates that the lower layer of reinforcement attains this temperature during a four hours' fire, and therefore it ceases to carry any of the load on the slabs. The upper layer attains 1,000°F and is therefore near its yield point. There are, however, several cases of failure with 1 in. cover to the lower layer of the reinforcement in which the collapse has occurred before that layer has attained 1,200°F. The tests appear to indicate that these cases are due to the spalling of the heated surface of the slab or to the development of cracks in the concrete which allowed the reinforcing rods to be heated by the flames at one or more points to 1,200°F. or more. The tendency



From Red Book 232.

REINFORCED CONCRETE SLAB R.C. 24.
Soffit of Slab after Test.

to spall can also be explained as the conductivity investigations proved that in the majority of cases the middle layer of the slab is at a lower temperature during the test than the mean of the temperatures of the top and bottom surfaces. This causes the top and bottom surfaces to be in lateral compression, whilst the middle layers are in lateral tension, and these stresses are large and probably exceed the breaking strength in the hotter portions of the slabs.

The reinforcement in those slabs which collapsed was drawn out at the places where it was severed, to conical pointed ends, one of which generally had a small cup formation.

From Red Book 234.

Reinforced Concrete Slab R.C. 24 (repaired).

Both Sides of Slab R.C. 24 having been Repaired. After the Original Test with Sand and Cement (2.1) it was slightly thicker than when first made. The Slab was then subjected to similar Tests with a further permanent deflection in the Centre of ½ in.

(To be concluded.)

ARCHED BRIDGES OF WIDE SPANS.

A Summary of a Paper read before the Swedish Concrete Institute in Stockholm.

By Dr. F. EMPERGER.

A HISTORICAL survey of the development of arches in bridge construction shows that the masterpieces of the Romans in this field of work have not been excelled up to most modern times, for whilst French engineers, as far back as the middle of the eighteenth century, constructed several fine bridges on the lines of the numerous and well-preserved patterns of Roman art in France, these later structures can only be described as adaptations of the older ones, and—notwithstanding the modern development of the theory of structures—the bridges, aqueducts and cupolas of the Romans of nearly twenty centuries ago are still equal to the corresponding structures of to-day.

The use of cast iron since the end of the eighteenth century in England, brought about a temporary departure from stone as a building material for bridges, and a number of famous bridges in various capitals of Europe bear witness to this period. The economic superiority of steel bridges at the present day compared with massive arch bridges is chiefly due to the lower prime costs of the former. Steel bridges are equally suitable for medium and for wide spans, but the supposed limitations of the span in other materials forms the chief obstacle to the general use of arches in stone, concrete, etc., and massive arch bridges of these other materials can only be of economic advantage if the difficulty of wider spans with flatter arches were to be overcome. To show that this difficulty no longer exists is the purpose of this paper.

The extensive use of hinges in metal bridge construction led to their introduction in stone arches by Köpke in the year 1880, and this, and a development of the theory of arches, led engineers to avoid designing statically uncertain and less-known fixed arches. Whilst, in the following lines, I dwell upon the advantages of hingeless arches and recommend them as the means by which greater spans may be attempted, I do not fail fully to appreciate the advantages of hinges, and only avoid them where they are not absolutely necessary and create an unnecessary weakening of the arch. The use of hinges is chiefly necessary in order to take up all changes and movements caused by settlement or shrinkage, yet a properly constructed arch will cease to move within a short time after the striking of the centres, and there is consequently little or no necessity for joints in the finished structure, as an arch is the ideal shape for absorbing subsequent movements due to temperature. It is quite a fallacy to consider joints necessary for the construction of wide spans, and my personal experience has taught me that such joints are quite superfluous, even with bad foundations, always provided that the latter were properly designed at the outset or that they have settled prior to the bridge being built. In all such arches the joints could be fixed later and the bridge thus converted into a monolithic structure, but if this were done, every care must be taken when the temporary joints are filled in with concrete, as the arch must be given a suitable form and proper arrangements of the reinforcement must be made, to allow for all stresses due to temperature.

Reinforced concrete was used in the construction of arched bridges in the year 1885, but there were several collapses as a natural consequence of the engineers concerned not making use of breaking-tests. Praiseworthy pioneer work was done in this respect in the year 1890 by the Austrian Committee for Arch Construction which experimented with arches of 66 ft. span, and whilst many expectations were not realised as far as the size of span was concerned, these experiments showed that there was no need for apprehension with regard to tensile strains.

Of the reinforced concrete bridges of the period, the Orelf Bridge (*Fig.* 2) of 300 ft. span and 1 : 3 : 2 pitch, is the largest main arch at present existing. It is a hinged bridge, but stone bridges like the Syratal Bridge (300 ft. and 1 : 5 pitch), the Luxemburg Bridge (280 ft. and 1 : 2·7) and the Isonzo Bridge (283 ft. and 1 : 3·9), which are all of the fixed type, make it sufficiently clear that no necessity exists for the use of hinges, especially as the flattest arches with a pitch of 1 : 12 were constructed on the fixed system, notwithstanding the fact that hinges are of greater importance with flat bridges. Hennebique, too, largely rejected the use of hinges; his largest bridge before the war was the one in St. Chaude with 220 ft. span and a pitch of 1 : 12; his flattest bridge had a pitch of 1 : 17. The greatest span actually used up to now is the bridge in Minneapolis (*Fig.* 1) of 407 ft. span and 90 ft. pitch, which is likewise of the fixed type and like all large bridges of this type has a high pitch.

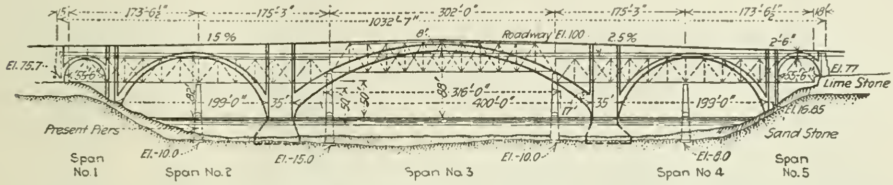


Fig. 1. Minneapolis Bridge.

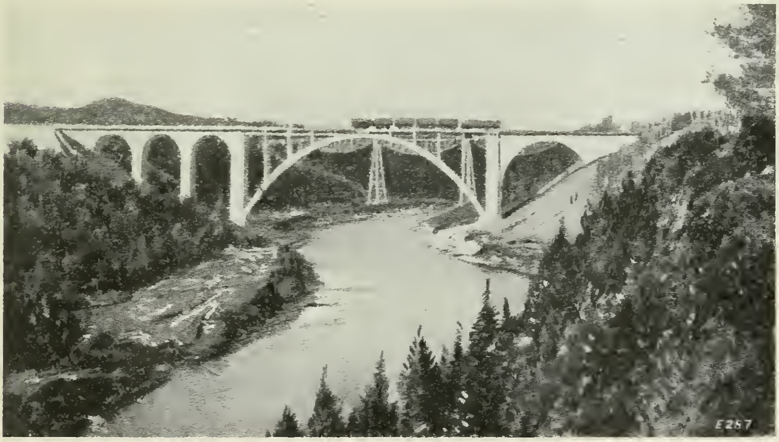


Fig. 2. Orelf Bridge.

If a large pitch of 1 : 6 and less were to be generally adopted, it would involve such great heights for clearance, special rock foundations, etc., that the use of such arches of such wide spans would be very rare and would only be used extensively if greater spans with a pitch of 1 : 10 could be erected on the common subsoil. If we increase the span of a structure it follows that all other dimensions must be correspondingly increased ; this is no peculiarity of arches but is applicable to other building elements, and this is one way in which the difficulty of wide span and stresses due to deadweight can be overcome in arch bridge construction. On the one hand, stronger construction of the abutments, and on the other a reduction in weight by giving the centre of the arch a slender form and building it of special pressure-resisting materials, and my chief task is, therefore, to discuss an arrangement which will increase the dimensions of the abutments, and reduce those at the centre of the arch so that all stresses will remain within safe limits.

Under ordinary conditions, an increase in the dimensions is naturally followed by an increase in the deadweight, and with larger arches the influence of the *deadweight* is practically the *only* factor of importance for the dimensions, and as it follows that the increase in the stresses can become greater than the increase in the cross section we soon arrive at a point at which the increase in the dimensions becomes useless, and only an increased *resistance* will lead to a solution of the problem.

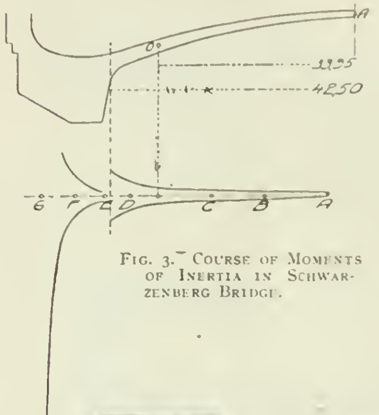


FIG. 3. COURSE OF MOMENTS OF INERTIA IN SCHWARZENBERG BRIDGE.

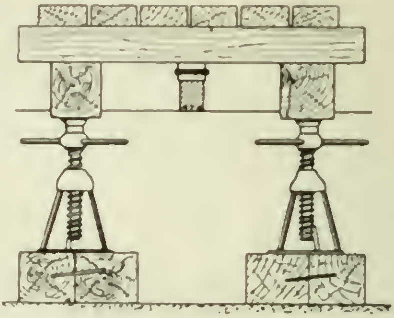


FIG. 4. LOADING ARRANGEMENT.

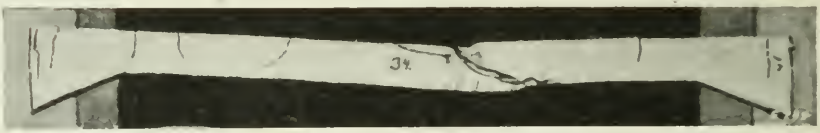


FIG. 5. BROKEN BEAM.

Several engineers have endeavoured to ascertain what is the greatest span which can safely be used for a single arch, and have considered 500–700 ft. as the maximum, though they have not shown any method of construction which (conditioned by the course of moments of inertia) was most suitable for the same. From a study of particulars of various well-known fixed arches collected by my collaborator, Mr. Gerhard Newman, I have found the ratio of moments of inertia from the crown to the base varies from 1 : 1 to 1 : 2·5, and Mr. G. Newman—who has examined the course of the maximum stresses at the edge for the whole arch of a recent design by Professor Melans, i.e. the bridge of Chauderon-Montbenon, which shows a ratio of moments of inertia from crown to base of 1 : 15—has arrived at the remarkable conclusion that with this arrangement, the positive and negative maximum stresses show such nearly equal values that the arch is of constant rigidity, notwithstanding the fact that its crown measurements are the smallest amongst a large number of those in existing bridges. This new arrangement therefore makes it possible to increase the span and shows the way to find new economic shapes for such great spans.

In connection with this, *Fig.* 3 shows the course of the moments of inertia in the case of the Schwarzenberg Bridge at the Building Exhibition of Leipzig in 1913, and enables us to judge how firmly the arch is fixed into the abutment. The moments of inertia calculated in the usual way for the points A, O and G, bear the ratio

1 : 5 : 16,000. The centre section consists of two ribs of about 225 sq. in. of surface (10 in. wide by 22½ in. high) and the width of the bridge is 16 ft. 8 in. If we compare the figures with the bridge at Minneapolis—the largest arch in the world—which (reduced to the same bridge-width) has 90 sq. ft. or 64 times the section in the crown, then we must conclude that this increase of section is quite out of proportion to the span, which is three times as large ; and this is the more remarkable as the pitch (1 : 4·5) of this largest bridge is far more favourable than that of the Schwarzenberg Bridge (1 : 7·5). A comparison of these figures clearly shows that there is a wide margin for the reduction of dimensions in the centres of these large arched bridges, and that their bulky and heavy construction is quite unjustified. By an arrangement such as that shown in *Fig.* 3 the arch proper is transposed between points A and O, and the clear distance of 142 ft. between the abutments is reduced, by means of the two consoles of 13 ft. each, to a span of 113 ft., i.e. to 80 per cent.

A further reduction can be obtained in future bridges, as the necessary tests have only been made since the bridge shown in *Fig.* 3 was built. A promising beginning was made during the years 1908 to 1912 by the Austrian Committee on Concrete-Steel Construction, under whose supervision tests were made with fixed beams supported by a 24-in. wall, the beams being fixed into the wall partly with and partly without enlarged or skewed ends.

Fig. 5 shows a broken beam, and *Fig.* 6 a general view of the result of these breaking tests. In all these experiments one and the same centre section (*Fig.* 5) was first of all examined, by means of the test load arrangement as shown. This centre section may be considered as that of half a plate one foot in width. The tests may be taken as corresponding to very flat arches, the skews at the supports corresponding to extended abutments of arches. The moments of resistance of a reinforced concrete section in the centre as well as at the point of fixture were actually measured and were not merely calculated.

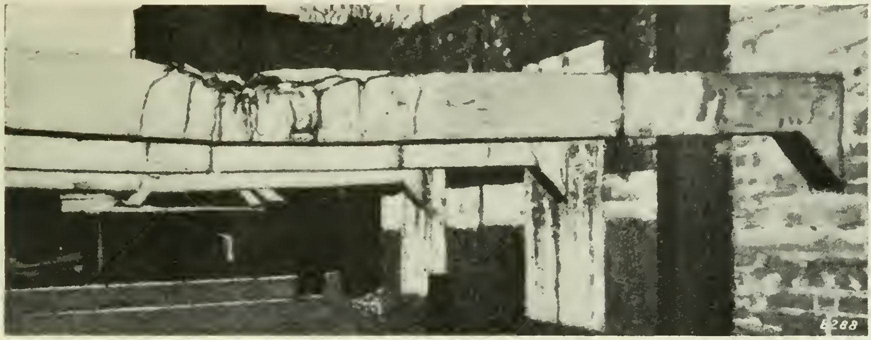


Fig. 6. Beams after Testing.

Fig. 7 shows the result of the tests on freely supported beams. The usual calculation for the breaking stress of a section which permits a tensile strength for iron of 54,000 lb. per sq. in. holds good in all cases except those beams which were enlarged at the supports. The equation

$$M_m = \frac{ql^2}{8} = W_e\ \sigma_e = W_e . 3{\cdot}923 = 229{\cdot}000 \text{ Kg-cm.}$$

which gives that moment of resistance for the section as being correct. *Fig.* 8 shows this and also the resulting cracks due to 2 and 4 loads on a freely supported beam.

Fig. 9 depicts the cracks in freely supported beams with enlarged ends and underneath a typical picture of the shape of the beam, from which may be seen the resulting reduction in the span through the adoption of skew ends.

An attempt was made to ascertain as to whether and how it would be possible to reduce the moment $\frac{ql^2}{8}$ for supported beams, by means of fixation to $\frac{ql^2}{24}$, or, in other words, to treble the carrying capacity of the beams. The supporting beams had a breaking load of about 40 tons, corresponding to the moment of resistance of 3,220,000 lb. per sq. in., so the reinforcement was arranged at the place of fixation in such a way that it would correspond to about double the moment of the centre, i.e. $\frac{ql^2}{12}$. *Fig.* 12 depicts the measures taken to fix these beams into the built-up abutments and should be compared with *Fig.* 6 which shows a single broken abutment, and the consequences of the tension strain at the connecting point. The same abutment was used several times for most of the tests, and the new beam was freshly concreted after chiselling out the old one.

Several of the tests were made in such a way that the fixing was somewhat weaker but never stronger, as it was not thought possible that these small provisions could do more than to take up and distribute the totals of the moments so that the sum of the moment (M_m) at the centre and the moment at the point of fixture (M_o) was otherwise than $M_o + M_m = \frac{ql^2}{8}$, which was considered as a definite formula. At first it was thought necessary to adopt the usual practice of loading the brick supports as well, but this, as well as the particularly careful bonding, proved later to be quite superfluous. The favourable results obtained were repeated with the simplest methods, and proved absolutely reliable. After the suspended beams were broken at 4 tons, it was to be expected that a fixed beam would have a breaking load of 12 tons, but the actual records show an increase to 16 or 17 tons throughout in tests without the skew ends and an increase to 25 to 27 tons in tests with skew ends with an equal moment of fixation. These results came as a pleasing surprise, as it was at that time the undisputed opinion in the profession that the effect of fixation upon the centre of a beam would at best be $\frac{ql^2}{24}$, and that, moreover, a complete fixture was very difficult to attain. To my deep regret, lack of means prevented further investigation of this important matter by further experiments on broad and extensive lines.

This need not hinder engineers from using the knowledge, clearly proved by facts, that a considerable reduction in the width of span of the centre beam can be obtained if the fixation is made in such a way as to provide a console-like connection of the abutment with the outer parts of the supports. The proof of the correctness of this assumption is shown by the fact that loads placed on the consoles have practically no influence upon the centre span. Owing to lack of means only a simple proof was possible. *Figs.* 10 and 11 show that by omitting the two outer of the four loads representing the total uniform load, the surprising result that the load capacity of the first beam was reduced from 17 to 8 tons and of the second beam from 27·9 to 9·5 tons was obtained. In both cases, and with and without the skews, an excess of the M_x moment resulted: which can neither be explained by the known moment of resistance of the two sections at the centre and at the point of fixation, nor by any other adjustment. The figures show what the result would have to be if for purposes of statical investigation the clear width were retained as width of span and if the influence of the horizontal drift caused by the frame support were not taken into calculation. This assumption is evidently incorrect, and a much smaller width of span must be taken as a basis for the moment of the centre if the efficiency of the centre section is to be considered. *Fig.* 10 gives a summary of some experiments without skew ends, and *Fig.* 11 one with skew ends, and the plans of rupture lines underneath show the effect of 2 and 4 loads. The quantity for M_x was found from the results found for M_m and M_o as shown by the tests. *Fig.* 15 gives the effect of the fixation and the deflections which took place in the centre of beams of different shapes under one and the same load.

This comparison load was, with freely supported beams, assumed to be somewhere in the neighbourhood of the breaking limit, and it will be seen that the deflection of the fixed beam is quite insignificant. Several experiments were also made with continuous beams, as shown in *Fig.* 12, and here also the incorrectness of the original assumption about the rectilineal form of the axis and the similarity of the course of the moment of inertia was proved and the favourable influence of these circumstances upheld. To what an extent this knowledge touches all branches of building construction may be seen in *Fig.* 13 which shows results of these experiments with the so-called "mushroom" flooring. These tests seem to prove the correctness of the contention of American engineers who negative the influence of two adjoining fields of mushroom flooring as given by an ideal continuity.

In their calculations they assume that the fields are carried singly by the consoles, the part of the bonding of which is clearly shown in the illustration, and they are evidently guided in this by the view that this method of calculation better corresponds to facts. The other extreme, i.e. that no continuity exists and that no transfer of strains from the neighbouring span takes place, is equally incorrect, but at the same time more serviceable than the present-day assumption. In this connection, it is necessary to say that with the experiments of the Austrian Concrete Committee the bondage of the tested beams must not be overrated, the ends of the beams were by no means invariably fixed in the true horizontal position. The angle of the departure from the horizontal was ascertained by exact measurement at the abutment, and found to be fairly considerable, proving that even in the experiments the fixation was not perfect. As a matter of fact, the fixation of an arch to its foundation as shown in

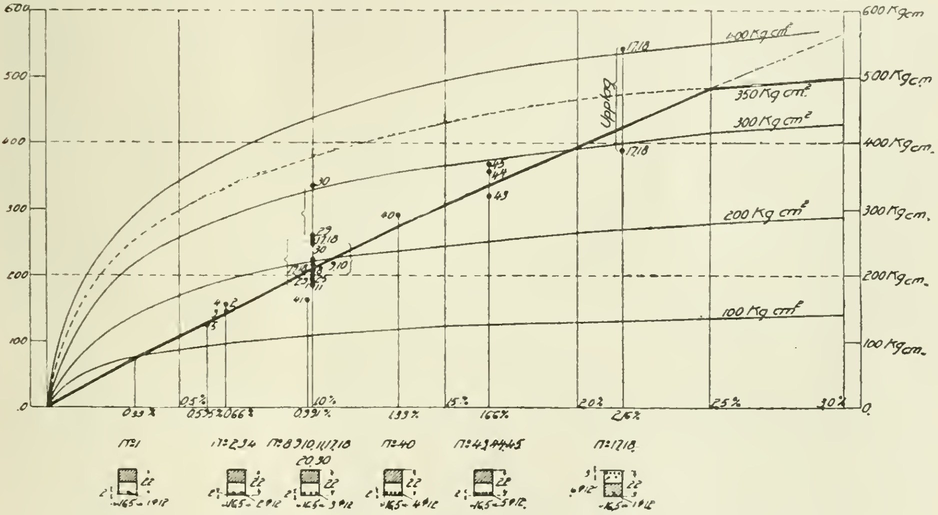


FIG. 7. RESULTS OF TESTS ON FREELY SUPPORTED BEAMS.
Note.—The carved line indicates bending resistance after six weeks (Control Beam).

Fig. 3 is far more reliable. When treating the whole of the test pieces as a frame system, it must be remembered that the pitch was about 1 : 4.

Other experiments on the determination of the true value of the moment of inertia, or the moment of resistance respectively, which in the usual calculation, with $n = 15$, is considered correct, and likewise in the second stage for the whole framework, were reported in detail in *Beton und Eisen*, 1916, in which the reduction of the moment of inertia of a reinforced section together with the increasing tension until rupture occurs, is extensively dealt with. The well-known formula for deflection (f) in the centre is $f = \frac{Pl^3}{EJ}$. In regarding this formula as significant for the change of form in the whole beam, it is of great importance to have exact knowledge of the true quantity of EJ. It is usually assumed that this quantity is the same over the whole beam, but the influence of an alteration of this quantity is, in case of a freely supported beam, chiefly dependent from the centre part, and it can also be proved (*Figs.* 9 and 12) that the influence of an alteration of EJ at the point of support of a freely supported beam is by no means so insignificant as may be thought.

Fig. 14 shows the course which EJ takes in a control beam with a load increased gradually to destruction, and the enormous difference which takes place within the range of the safe load will be noticed, and in practice there is no beam with a uniform *EJ*. This difference in the case of the freely supported beam only comes into consideration at that change which takes place near the supports between stage I and stage II. This is usually disregarded, but it must not be neglected with beams where the change of tension is near the centre as is the case with a beam fixed at the ends or with arch. In a fixed beam, stage I with its enormous moments of inertia will remain at the place where the change of tension takes place, and will make itself felt like a partition between the centre part of the beam and the console connected to the abutment (*Fig.* 10), and conditions may then occur to cast doubt on the value of the connection between the centre part and the two outer consoles of a beam and considerably reduces the effective width of span of the centre part. For this reason it is very doubtful whether the continuity, or better, the homogeneity of a beam is maintained constant until the rupture point is reached.

Loads may be added or taken away from the sides without in any way affecting the centre. The beams examined had, through their walls, sevenfold the bearing capacity of the freely supported beam when with skews and fourfold when without skews, instead of only a threefold increase as would be expected according to theory. Hence a beam which, when freely supported, may rightly have a span of say 100 and which, when perfectly fixed and bonded, would allow, according to theory, an increase of the span to 173, would, according to the tests mentioned above, allow a span of 200 and 265 respectively with and without skews.

These tests prove that without skews the bearing distance of the centre is reduced by about half and by aid of skews by about one-third ; this gives wide possibilities of economic importance of which full advantage should be taken in the present shortage of iron for considerably reducing the costs of building.

There are very few analogous tests on arches and these are not to the point, like the older tests with beams. On the other hand, in the tests described above, the beams may be practically considered as flat arches of about 1 : 20 and so permit of conclusions for flat arches to be drawn which apply to the importance of skews or enlarged ends, which was never sufficiently appreciated, and it is probable that without the foregoing tests they would never have been considered anything other than a luxury to be indulged in only by a particularly careful engineer or contractor. Directions for the use of skews have never been published and their effect has never been properly considered.

To clear up this question the experiments described were undertaken by the Austrian Committee for concrete-steel construction. The beams had skews of three sizes : $\frac{1}{16}$, $\frac{1}{8}$, and $\frac{1}{4}$ of the span. The smallest skews of 10 in. and only 8 in. height had a small effect and there was a weak point between the beam and the skew. The medium-sized skews 20/8 gave excellent results. The large skew 40/16 increases the carrying capacity to such an extent that the available load was not sufficient to secure the destruction of the beams. The effect of skews on arches would have to be ascertained by similar tests, which would also show the dimensions to be chosen in order to obtain a definite result by a reduction of the span. At present it is necessary to rely mainly on guesswork. In the light of these facts it would have been better to provide the abutments of the Schwarzenberg Bridge with stronger skews as shown in *Fig.* 15. The projection of these skews would, in accordance with the tests, be 51 : 17 = 3 yds. The change of moments causes an altered course of moments of inertia and brings about a large accumulation of moments of inertia so that the part, which in theory can be limited by a joint and which statically limits the centre part of the arch, can be pushed further out. It is thus made possible for an arch of 140 ft. clear span to have a bearing centre of only about one-third, i.e. 50 ft. span.

(*To be concluded.*)

THE SUCCESSFUL REPAIR OF A CONCRETE SHIP BOTTOM.

By WALTER R. HARPER, United States Shipping Board.

The following particulars of the successful completion at Galveston, Tex., of an unusual piece of ship repairing, where a large portion of the bottom of the 7,500-ton concrete ship "Latham" has been replaced, may be of interest. Our information is taken from an article in "Concrete, U.S.A."—ED.

THIS ship was damaged early last July by running on the rocks of the north jetty of the breakwater at the entrance of the harbour at Tampico, Mexico, when the master of the ship attempted to enter this dangerous harbour without a pilot. Many doubts have been expressed by shipping men not familiar with this new form of ship construction as to the possibility of making successful watertight connections between old and new concrete surfaces, but the successful completion of the repairs on the *Latham* proves that when proper methods are used, this type of ship can be repaired successfully with greater rapidity and much lower cost than a steel ship. Doubts have also been expressed by contractors and others accustomed to using concrete composed of the ordinary mixtures used in buildings, etc., as to the possibility of obtaining a waterproof concrete on the bottom of these ships, which is only 5 in. in thickness and is subjected to a hydrostatic head of 44 ft. during the test of the ship's tanks.

No waterproofing compound, or other material, was used in the mixture of the concrete for this ship to make it waterproof and oilproof. Its unusual resistance to the penetration of oil and water is due entirely to the endeavour to get a dense mixture, which was obtained by a careful selection of materials, careful supervision of pouring and mixing and to the concrete being rammed and settled by special methods developed by the engineers of the Shipping Board during this construction. The cement was a re-ground product, 90 per cent. passing a 200-mesh sieve.

Samples of pieces of concrete which have been cut from the *Latham's* oil tanks during the present repairs show no penetration of the oil in the concrete, notwithstanding the fact that the concrete had been immersed in oil for three months, where it formed a portion of the oil tanks on the ship, and was under a pressure of 20 ft. to 30 ft. of oil.

The *Latham* is the property of the United States Shipping Board. The *Latham* and her sister ship, the *Selma*, are two of the largest concrete ships in the world—431 ft. in length over all, 54 ft. beam and 36 ft. moulded depth, 7,500 tons deadweight. They are oil-burners and have triple expansion engines of 2,800 h.p.

At the time of the accident the *Latham* was making a speed of ten knots per hour, which caused her to be driven over the rocks of the jetties, leaving four parallel gouges from 4 ft. to 6 ft. wide and nearly the entire length of the ship. No direct punctures were made, but the concrete in the gouges was crushed and held in place by the reinforcing steel in much the same manner as a piece of broken wired glass would be held. Notwithstanding the extensive damage to the bottom, the ship was able to proceed from Tampico, Mexico, to Galveston, Tex., under her own steam and without a convoy. There were only three of the damaged tanks that could not be pumped dry with the ship's pumps.

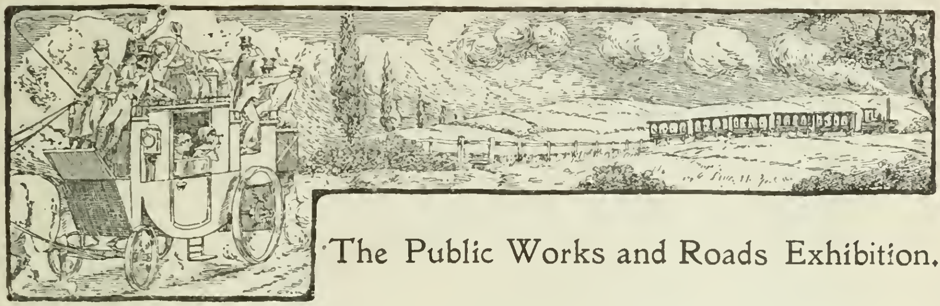
Upon reaching Galveston the ship was dry-docked and the work of repairs started. The damaged concrete was cut out; the reinforcing rods straightened; the oil removed from rods and edge of concrete; wood forms were then placed, and the new concrete poured in the damaged portion. Great care had to be taken to get bond between the old and new concrete. As the bottom of the ship also forms the bottom of the oil tanks, all surfaces were covered with crude oil, which had to be removed, as any oil in the joint between the old and new concrete would have destroyed the bond. All shattered concrete was removed and the edge of the damaged portion cut back into the solid concrete until a firm face was made. (This work is similar to that of a dentist in preparing a cavity for a new filling.) All traces of oil were removed from the edge of the joint, and from the reinforcing steel by sand blast, or by a steam jet. The dust on the new edge of the concrete, caused by cutting and deposit by the sand blast, was removed by going over the surface with an air hose with air at a pressure of about 60 lb. This removal of the dust between the old and new concrete is of great importance. After the forms are placed on the bottom the entire surface of the concrete joint and the forms were thoroughly saturated with water, in order that there should be no absorption of the water from the concrete before setting. Just previous to pouring the concrete, the joint which had been saturated with water was sprinkled lightly with dry cement. The concrete was rammed and agitated, in order to settle it around the intricate mass of reinforcing steel rods. By these careful methods an absolute watertight job was obtained, and when this ship was lowered from the dry-dock into the water there was not a single leak, or even a sign of moisture throughout the entire work. The ship made her first voyage after the repair March 9, 1921.

The mixture of the concrete used in this repair work was one part cement, one part fine aggregate and one part coarse aggregate ; making a 1 : 2 mortar. The mixture used was comparatively dry, being of the same consistency as used in the original construction. In order to obtain the maximum strength of the concrete, the water is measured as carefully as the cement and aggregate. The concrete in the *Latham* and in other concrete ships built by the United States Shipping Board was made of a carefully selected clay baked into clinkers in a brick kiln at a temperature of about 2,000° F. After cooling, the clinker is crushed in a stone crusher and run through a ½-in. screen : the ½-in. size being taken for the coarse aggregate and used in place of gravel. The finer material is used in place of sand. This material is the result of many experiments carried on by the Concrete Ship Section of the United States Shipping Board, in their endeavour to secure a light concrete and one that would stand at least 4,000 lb. per sq. in. in compression. Concrete made of this material weighs approximately 105 to 110 lb. per cu. ft., compared to 150 lb. per cu. ft. for sand and gravel concrete. This light weight concrete, in cylinders 12 in. high and 5 in. diameter, crushes at from 5,000 to 6,000 lb. per sq. in. In a ship the size of the *Latham* about 1,000 lb. in weight has been saved by this light aggregate concrete, which, of course, means that the ship has this much less displacement and can carry a thousand tons more of cargo.

Even with the use of this light material the concrete ships are heavier than a steel ship of the same size and are handicapped in carrying a heavy cargo such as steel, ore, or oil, but with a light cargo, such as cotton, sisal, or general merchandise, a concrete ship has a decided advantage over a steel ship and has a greater earning capacity, owing to the fact that the cargo spaces are necessarily larger than those of the steel ship in order to obtain the buoyancy, and if light cargoes are selected these ships will have a greater earning capacity than a steel ship of the same size.

There are at this time built, and in commission, only nine ocean-going concrete ships in the world : all of them built in the United States.

The concrete ship *Selma*, sister ship of the *Latham*, met with an accident similar to that of the *Latham*, by running on the jetties of the breakwater at Tampico. The master of the *Selma* was also trying to enter this dangerous harbour without a pilot, which in all probability was the main cause of both accidents. Notwithstanding the accidents to both the *Selma* and *Latham*, which necessitate these extensive repairs, the concrete ships have been successful. The advantages claimed for them over a steel or wooden ship are the original cost of building, which is much lower ; the repair and upkeep, which is far below the other vessels ; the concrete ship has no tendency to deteriorate by rusting, or being injured from corrosive action of sea-water, or destroyed by teredo or other forms of sea-worm which tend to destroy wood-ships. Repairs can be made at a lower price and much more rapidly than on a steel ship.



The Public Works and Roads Exhibition.

WORKS of public utility are being put in hand to such a large extent with a view to relieving the prevailing abnormal amount of unemployment that the Public Works and Road Transport Exhibition, held at the Agricultural Hall at the latter end of last month, came at a very appropriate time, and the large number of exhibits were of considerable interest to those concerned with such schemes. It may appear to be an anomaly to urge the adoption of labour-saving devices on schemes primarily promoted to absorb as much labour as possible, but after all the ratepayers and taxpayers are entitled to as good a return as possible on money spent on what are in some cases admittedly uneconomic propositions; if, for instance, a certain sum be voted to employ, say, 100 men on road works, why should not those men construct twice as many miles of roads with the aid of machinery as they would be able to do without? By the use of machinery wherever possible, not only will the greatest value be obtained for the expenditure but work will also be made for the engineering industry in the manufacture of the plant.

Much of the plant shown at the Exhibition is already so well known as not to require describing, but a few of the exhibits were shown to the public for the first time, and it is to these that the following notes are chiefly devoted.

CONCRETE MACHINERY.

A machine for mixing concrete on an entirely new principle was shown by the *Ransome Machinery Co.* (1920), Ltd., of 14–16 Grosvenor Gardens, S.W.1. The idea embodied in this machine (the "Aero") is the separation and coating with cement of each particle of wet aggregate as it passes through the drum of the machine, thereby

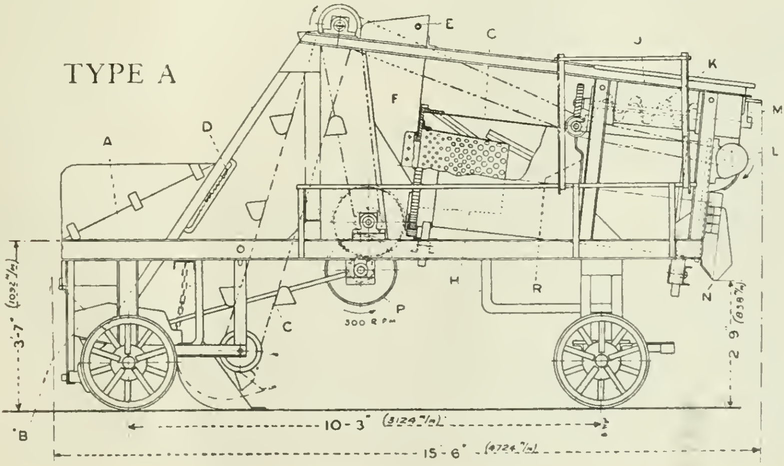


FIG. 1. THE AERO MIXER, TYPE A.

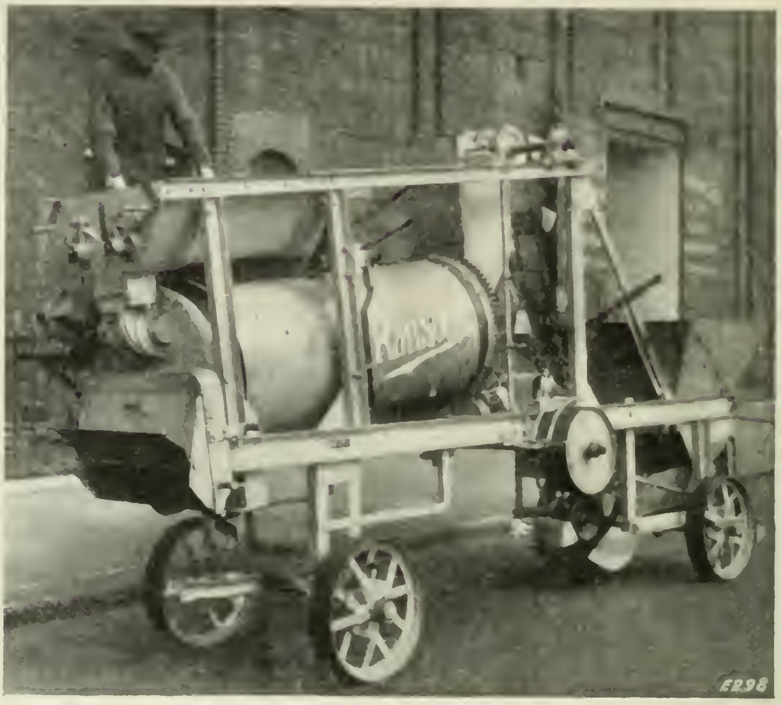


FIG. 2. THE AERO MIXER. TYPE A.

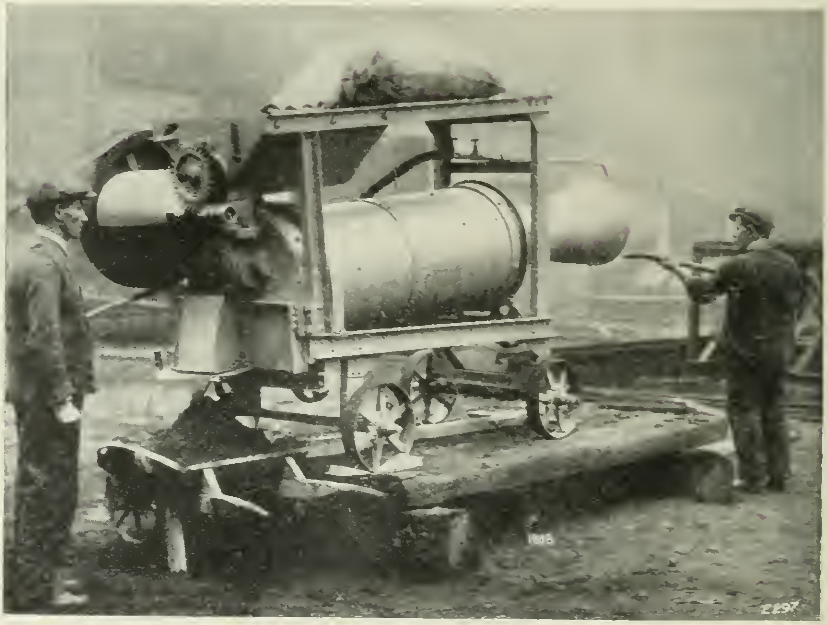


FIG. 3. THE AERO MIXER. TYPE B.

ensuring that no single particle of stone or sand is without a layer of cement covering its entire surface. This, of course, must always be the primary consideration in the manufacture of concrete if it is to be of first-rate quality, and it is claimed that the "Aero" method is the most economical by which it can be obtained. The proportions of stone, sand, cement and water are all automatically regulated by the machine by feed regulators which are set to supply the various proportions specified, and thus the human factor, which is always liable to play havoc with a carefully-prepared specification, is eliminated so far as gauging the quantities is concerned. The large hopper has a partition down the centre, and stone or gravel is fed into one side, and sand into the other. A separate hopper is provided for cement. The stone and sand are delivered through doors in the hoppers, in pre-determined proportions, to a shaker-tray, where they are thoroughly mixed together. From the shaker-tray the mixed aggregate is conveyed by a bucket-elevator to a chute down which it passes to the drum, and as it drops into the drum from the chute it is sprayed with water, which also falls on to the aggregate at the bottom of the chute before it passes into the revolving mixing drum. The wet aggregate passes from the bottom of the chute to a revolving screen inside the top of the drum, through which it drops in separate particles into the drum. The inside of the drum is fitted with steel angles which, as the drum revolves, carry the aggregate round and throw it backward and forward. It is here that the cement is added in the form of a fine spray from a blower or spraying fan. The drum is continually filled with a cloud of dust-like cement, which adheres to the wet stone and sand as it is tossed about by the revolving blades. From the drum the mixed concrete is automatically discharged in a continuous stream. Thus no labour is required in addition to that necessary for keeping the hoppers supplied and removing the concrete, and no stopping or restarting the machine are necessary. As only small quantities of material are in the machine at one time, they stand the best chance of being thoroughly wetted and coated with cement. The machine is made in two sizes, types "A" and "B." Type "A" (*Figs.* 1 and 2) has an output of 8 to 10 cu. yds. per hour, and type "B" (*Fig.* 3) has an output of 4 to 5 cu. yds. per hour. Both machines will take aggregate up to 1½ in. The chief difference between the two types is that type "A" is fed by way of hoppers from sacks, while type "B" is fed by hand (shovel) through a funnel. It is claimed that by the automatic and accurate regulation of all the constituents of the concrete by this machine considerable economy in cement is possible. The machines are British made throughout. This firm also showed a selection of their well-known concrete machinery, including the "Lightweight" mixer (batch type), a mixer with travelling bucket and boom, steel barrows, sheet piling, and a pile extractor.

Four apparatus not before shown in this country were exhibited by *The Zondervan Works* (21–23 Rue Albouy, Paris), in the form of a hand block-making machine, a hoist, a crusher, and a mould for concrete tubes.

The block-making machine (*Figs.* 4 and 5) forms hollow blocks, the hollow being formed by a metal core which is pushed into the mould by means of a lever while the mould is being filled. The core moving on a horizontal plane enables the blocks to be made on the face-down principle. After the concrete has been tamped and smoothed off in the usual manner, the mould is turned on end, the

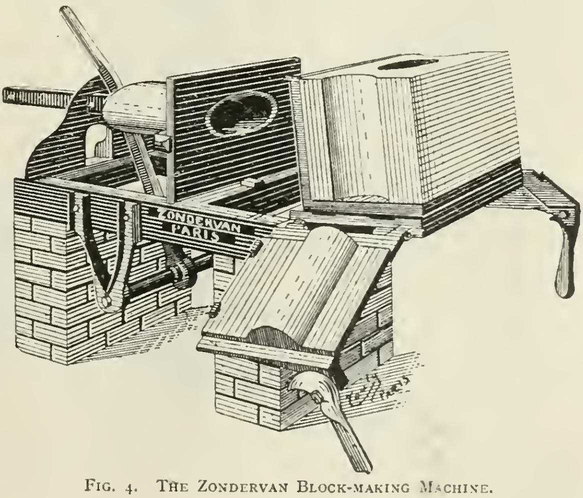


FIG. 4. THE ZONDERVAN BLOCK-MAKING MACHINE.

sides released, and the block removed on a pallet. The machine produces blocks measuring 16 in. by 8 in. by 8 in., and has an output of 20 blocks per hour.

The crane (*Fig.* 6) has two jibs, and is so designed that the driving wheel, while turning in one direction, simultaneously winds up the cable of one jib while lowering that of the other. Thus the time lost with a single-jib crane while the cable is being raised and lowered is to a large extent eliminated, as while one is ascending the other is descending. A device fitted on the yoke axle causes the jib automatically to swing inwards and stop where required, when the load reaches a pre-determined height, so that no further manipulation of the operating gear is necessary from the time the load leaves the ground until it is over the spot where it is to be placed. The crane is made for hand operation and also fitted with a petrol engine. If required, one jib only may be worked.

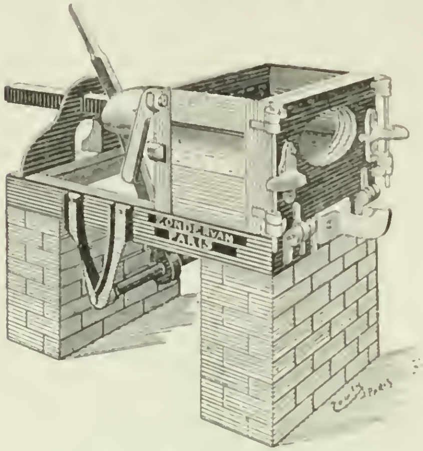


Fig. 5. The Zondervan Block-making Machine.

A new mould for casting concrete tubes was exhibited on this stand. The mould is very strongly constructed and the arrangement for releasing the inner and outer members is of a simple character. A stone crusher was shown in operation, with an output of from 3 to 5 cu. metres per hour. This machine embodies a device whereby one of the cylinders may be moved in a horizontal direction and separated from the other so as to open a passage for pieces of metal, etc., which may inadvertently get into the hopper.

A model pile-driving plant with a McKiernan-Terry hammer in operation attracted much attention on the stand of the *British Steel Piling Co.*, of Dock House, Billiter Street, E.C.3. In addition to their other well-known pile-driving equipment, this firm also exhibited their "Zenith" and "Zenith Pup" concrete mixers, concrete placing plant, loading skips, ballast washers, jacks, friction winches, etc.

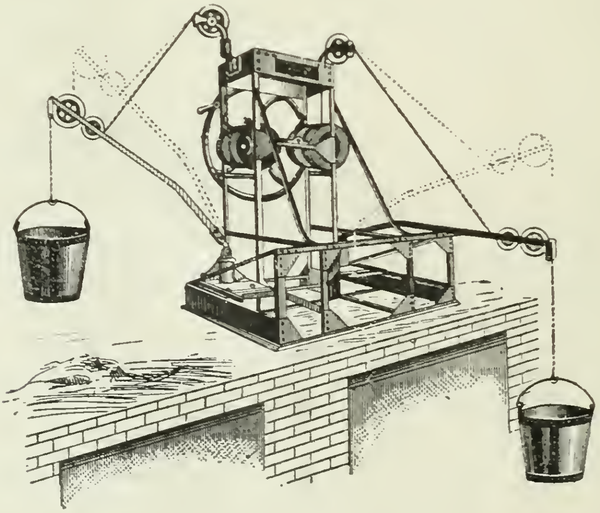


Fig. 6 A New Type of Crane.

Messrs. Building Products, Ltd. (3 Columbia House, King's Road, S.W.3), who specialise in auxiliaries for reinforced concrete construction, had on view a wide selection of their well-known products, including the useful " Rigifix " fittings for casting into concrete in order to avoid cutting when fixing pulleys, shafting, etc. ; bar-bending and bar-cutting machines specially designed for dealing with reinforcement rods, angles and plates, and their various specialities for improving, hardening and waterproofing concrete.

A selection of plant for roadmaking was exhibited by *Messrs. Stothert & Pitt, Ltd.* (11 Victoria Street, S.W.). Two types of " Victoria " mixer were shown, a ½-yard paver with side loading and swinging boom with travelling bucket, and the " Dri-crete " machine for making concrete blocks with waterproof face.

The handy and efficient " Australia " block-making machine, and the " Tonkin " mixer (the latter embodying several improvements in detail) were exhibited by the *Australia Concrete Machinery and Engineering Co., Ltd.*, of 607 Salisbury House, London Wall, E.C.2.

Messrs. Hugh Wood & Co., Ltd. (65 Fenchurch Street, E.C.3) showed a bucket elevator mounted on a three-wheel truck, which enables it to be turned in a complete circle, with either drive wheel as a centre. In order to obviate the necessity for cleaning up the pile before the buckets are advanced into it, the buckets are wider than the boom. It is claimed that the machine will load a five-ton truck in from 8 to 10 minutes. The drive is by either electricity or gasolene, the engine being mounted on the truck.

The Allied Machinery Co., Ltd. (132 Queen Victoria Street, E.C.4) had on view an extensive range of contractors' plant, including a 7-ton road roller, a bucket loader and conveyor, an elevator and a " Lakewood " mixer and paver. We illustrate a 45 ft. conveyor (*Fig.* 7) with a smooth rubber-covered belt for operating at angles up to 25 degrees. This type of conveyor is supplied in lengths from 15 ft. to 60 ft., with a width of 18 in. The framework is designed to secure adequate strength with a minimum of weight. The belt, which has an average life of up to three years under service conditions, may be tightened by means of a screw adjustment. The " Lakewood " paver of ½ cubic yd. capacity, with a 25-ft. boom and travelling bucket, and power loader was also shown.

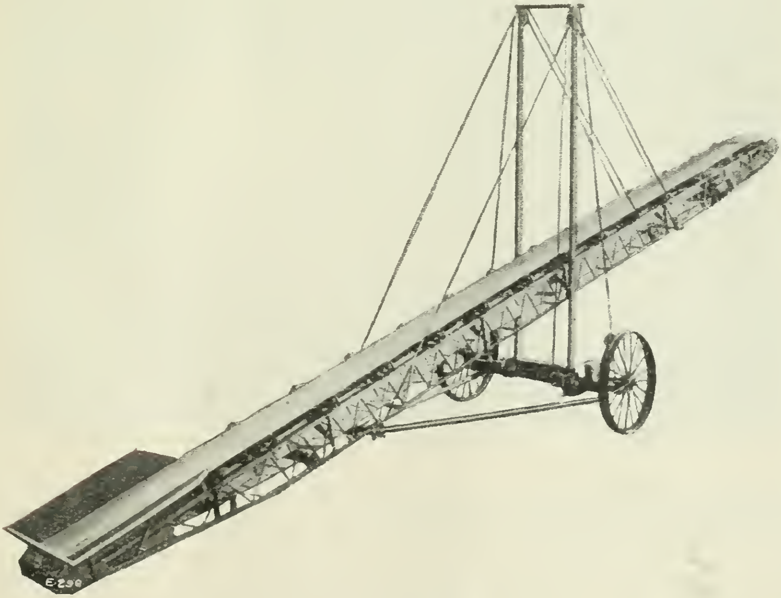
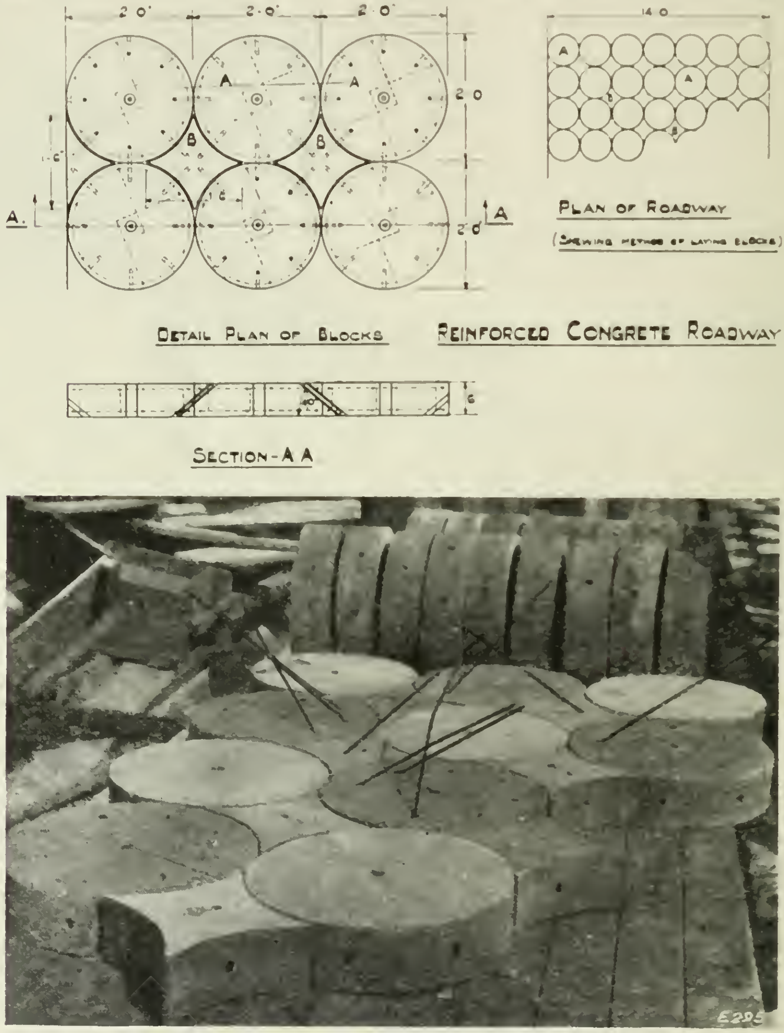


FIG. 7. A 45-FT. CONVEYOR.

PRE-CAST CONCRETE ROAD.

Messrs. Spagnoletti & Grunspan (of 8 Victoria Street, S.W.1) demonstrated a patent form of pre-cast concrete road construction, which we illustrate (*Figs.* 8 and 9). The road is formed mainly of pre-cast concrete discs 2 ft. in diameter and 6 in. thick, with a 1-in. diameter hole through the centre, reinforced at top and bottom. The spaces formed between the blocks in juxtaposition are filled by specially-shaped blocks, which are also pre-cast. The blocks are held together by dowel pins, which are fitted from the surface into holes left for the purpose in the blocks. The covering material of the road, *e.g.* asphalte or grout, is worked into the spaces between the blocks and into the holes left in the centres, thus further keying the blocks together. The discs, filler blocks, and dowel pins form the only three units of which the road is built. When building a road, the blocks can be manufactured at a depôt, preferably near the site of the road, where they can be stored until matured. As soon as the under-bed of the road has been prepared the blocks can be laid and keyed together by unskilled labour.



FIGS. 8 AND 9. SHOWING DETAILS OF PRE-CAST CONCRETE ROAD.

The blocks are, of course, of considerable weight, but owing to their circular shape it is possible for one man to roll them into position.

The outstanding advantages claimed for this system are as follows : (1) The road is continuous and at the same time resilient owing to the large number of discs keyed together ; (2) there is no direct line of joint, the latter being a wave ; (3) the road has no tendency to crack ; (4) it can be taken up and relaid at little expense, should alteration to the gas, water, or electric mains be required ; (5) it gives a sound foundation ; (6) it is not affected by expansion ; (7) a good concrete is assured by seasoning being possible at a depôt. The system is, we understand, being laid on the Continent and also in some parts of this country.

REINFORCEMENT

Several of the firms who specialise in reinforcement for concrete structures and roads exhibited their various systems. *Messrs. Johnson's Reinforced Concrete Engineering Co., Ltd.* (Lever Street, Manchester) showed the " Lattice " and " Keedon " systems, and " Bricktor " reinforcement for brickwork. *Messrs. Brown and Tawse, Ltd.* (3) London Wall Buildings, E.C.2) showed their new system of reinforcement for roads, a pile column and frame, reinforced concrete fence posts, and hoops and links ; on this stand a number of reinforced road slabs were shown in position. The value of " B.R.C. Fabric " as a road reinforcement was demonstrated by the *British Reinforced Concrete Engineering Co., Ltd.* (1 Dickinson Street, Manchester) by means of models and specimen road slabs, and the extensive manner in which it is now being employed was shown by a large number of photographs of roads under construction in which were to be seen coils of the fabric. Expanded sheet steel reinforcement, rotary " Diamond Mesh " expanded steel, expanded metal lathings, and " Exmet " reinforcement for brickwork were among the exhibits of the *Expanded Metal Co., Ltd.*, of York Mansion, Petty France, S.W.1. *The Walker-Weston Co., Ltd.* (7 Wormwood Street, E.C.2) exhibited, by means of samples, models and specimen slabs, the uses of their patent double-layer reinforcement ; this sytem is now being employed on the new arterial roads in Manchester, the North Circular Road, Middlesex, and a number of roads in Middlesbrough ; *The Barb Engineering Co.* (Saltney, Chester) displayed their " Wonpees " road fabric ; this material is supplied in a continuous roll, and has a tensile strength of up to 40 tons per square inch. Where the wires cross they are formed into a homogeneous mass by a special process. The larger part of the stand of the *Indented Bar and Concrete Engineering Co., Ltd.* (of Queen Anne's Chambers, S.W.1) was devoted to samples of " Triangle Mesh " road reinforcement, and the firm's well-known indented bars were also shown.

CEMENT.

The stand of *Messrs. Super Cement, Ltd.* (of 10 Upper Woburn Place, W.C.1), contained test pieces of Super Cement and concrete in which it had been used, and also many photographs of large works at home and abroad for which it has been specified. An interesting exhibit was a piece of cement which had been joined after the face had been washed with Super Cement, and then broken ; the break occurred not at the joint but in an entirely new place.

The stand of the *Torbay and Dart Co., Ltd.* (Victoria Road, S.W.10) was devoted to a display of " Novoid " cement waterproofer and void-filler, and its void-filling properties were demonstrated by means of enlargements of photographs taken under the microscope. Among an interesting series of photographs shown on this stand was one of the experimental tank at the National Physical Laboratory, Teddington, in the construction of which " Novoid " was used.

ABSTRACTS FROM THE FOREIGN PRESS.

A PORTUGUESE WATER TANK.

Signor Augusto Vieira da Silva of Lisbon, has designed and supervised the erection in that city of a concrete water tank with a capacity of more than 80,000 gallons on a support 30 ft. high, and with a supplementary tank of 12,000 gallons at the base. The important structural details of the tank do not present any particularly novel features, but it is interesting as showing the rapid strides made by reinforced concrete in Portugal.—*Revista de Obras publicas e Minas de Portugal.* 1920.

RUST-PREVENTION IN REINFORCED CONCRETE.

The development of rust in reinforced concrete and the best methods of prevention have recently been examined by Dr. Goslich of Berlin with the assistance of an influential committee. Three typical Portland cements were used, the cement mortars consisting of cement and sand in the ratio 1 : 2, 1 : 3, and 1 : 5 respectively, and the reinforcing rods 0·4 in. diameter were covered to various extents.

The results show that to ensure the reinforcement being properly protected it must be covered with at least 0·8 in. of 1 : 2 cement-mortar. The sizes of the sand grains and of the interstices between them are less important than the richness of the mixture. A 1 : 2 mixture is superior to 1 : 3 as regards prevention of rusting, and 1 : 5 is satisfactory if the reinforcement is sufficiently deeply embedded.

If the conditions are sufficiently severe, rusting appears to be inevitable unless the reinforcement has been covered with a waterproofing agent.—*Zement*, 1921.

THE EFFECT OF RAIN ON HOUSES.

Professor Nussenbaum, of Hanover, has for many years been interested in investigating the effect of rain on houses built of various materials, and has pointed out that if rain drives heavily against a wall of a house built of porous material without showing signs of dampness on the interior, it is essential that the wall shall be waterproof or sufficiently thick and porous to retain all the rainwater within its pores and to give it up again to the outer air when the rain has ceased.

If the walls are quite dense and unabsorbent, the interior of the house will show condensation when the exterior is cooler than the interior, but such condensed moisture has no connection with the rain but is dependent on the thermal conductivity of the dense concrete, coupled with its inability to absorb the moisture condensed on it. The obvious remedy is to make the interior of the wall sufficiently porous to absorb the condensed moisture.—*Zement*, 1921.

A PRESSURE CONDUIT OF REINFORCED CONCRETE.

A conduit for the supply of water under great pressure, for supplying the hydro-electric works of Rioupéroux (Isére), has been built of reinforced concrete, as it was possible, when using this material, to form the pipe according to the shape of the ground on which it lies, and by that means to avoid much unnecessary expense, as the best situation of the pipe involved its passing under various structures, any interference with which was very undesirable.

The conduit is 2,040 ft. in length, and 8 ft. in diameter. The water-level at the inlet is 1,900 ft. above datum, that at the exit is 1,700 ft., so that there is a static-pressure equal to a water-column 200 ft. high. The ends of the conduit are of steel, so as to ensure a perfect connection with the plant.

The conduit pipe has a double transverse reinforcement throughout its length, the steel rods used being $\frac{1}{2}$–$\frac{5}{8}$ in. diameter, with horizontal tie-rods $\frac{3}{8}$ in. diameter, and placed rather more than an inch apart. The joints in the reinforcement are simple hooks, no solder being used. In the bent portions of the conduit extra reinforcement is employed.

The thickness of the wall of the conduit varies from 4–8 in. The concrete is a 1 : 2 mixture.

The centreing used for the greater part of the conduit was the "Parapline," which had previously been used in other cases, but for the more difficult of the curved portions wooden centreing was used.

The interior was made smooth with a finishing coat 1¼ in. thick.

To ensure complete impermeability, the greater part of the conduit was fitted with a steel tube which was placed between the two rings of reinforcement, the joints being welded autogenously. This steel-work did not in any way affect the strength of the concrete; it was used solely to prevent any penetration by water under the high pressure employed.

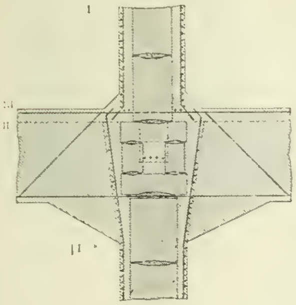
In so long a conduit, placed at such an inclination, the chief precautions to be taken are to resist the pressure of the water and the bending action due to the weight of the conduit, the irregularities in the ground, the effect of settlement and any internal changes due to contraction of the cement and to variations in temperature.

Prior to being used, the conduit was filled with water, left overnight, and then gradually emptied. It was next inspected, with the greatest attention to detail. It was then filled rapidly and examined externally.

Among many concrete pipes of large size, the one at Rioupéroux deserves special attention because of its great diameter, the pressure to which it is subjected, and its suppleness and adaptability to the surface of the ground. It shows that reinforced concrete is a particularly suitable material for works of this nature.—*Schweizerische Bauzeitung.*

CONCRETE PILLARS WITH A STONE CORE.

According to some experiments made by Dr. Emperger, of Vienna, the use of a stone core enables a large amount of steel rods, which would otherwise be needed for reinforcement, to be spared. In some of the experiments, the use of 1 cub. yd. of stone effected a saving of 4 tons of metal. The use of a stone in this manner effects a large saving in the amount of spiral reinforcement which would otherwise be needed.



The arrangement preferred by Dr. Emperger is shown in the accompanying illustration, which represents a vertical section of a pillar and floor. The stone core is built first, and the centreing fixed for the floor. The reinforcement for the floor and the stones are then placed in position, after which the floor is made, and the reinforcement for the upper pillar is duly fixed. The upper pillar is then completed in the usual manner.

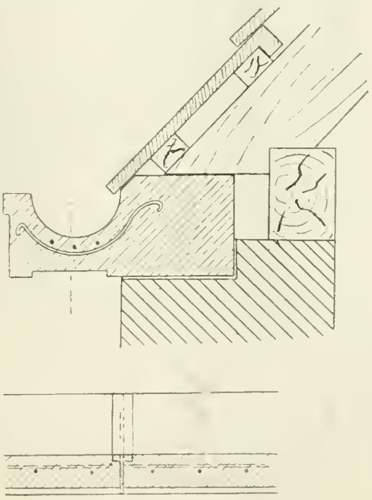
With a stone core, there is very little risk of cracking or fracture, and the combination of stone and concrete offers considerable economy where stone is cheap and steel is dear.—*Schweizerische Bauzeitung.*

CONCRETE GUTTERS.

Gutters were made of concrete more than ten years ago, but more recently they have been considerably improved and are now quite impervious. Concrete gutter blocks are about 3 ft. in length. and 16 in. wide. The joints between the blocks are made of cement mortar, and after being finished level with the gutter they are coated with a waterproofing material.

Each block is reinforced longitudinally and transversely, as shown in the sketch,

A massive concrete gutter has an attractive appearance, and it is claimed that when properly made it is no more expensive than a galvanised gutter.—*Zement*, 1921.

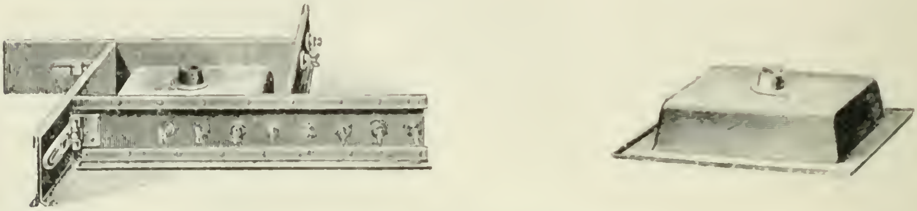


CONCRETE SINKS.

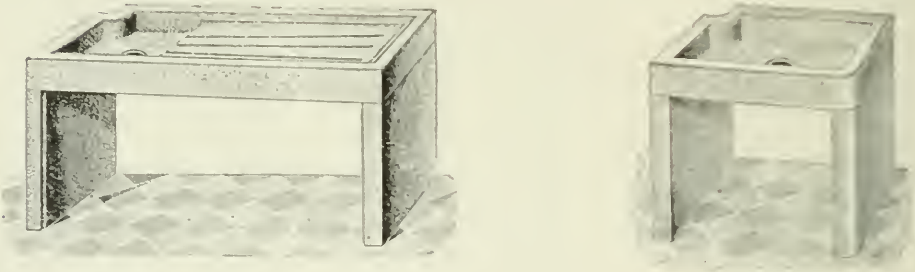
The advantages to be derived from making the sinks on the site of a series of cottages, are obvious, but no one appears to have thought of doing this until quite recently.

The moulds are of iron, and consist essentially of an adjustable exterior mould and a cone which forms the hollow of the sink. By suitably arranging the former, it is quite easy to produce a single sink or a combined sink and drainer.

The sinks may be made of plain concrete, but a better appearance is obtained if the aggregate consists of white marble in the form of small chippings. The most suitable mixture is 1 : 3.—*Zement*, 1921.



Framework and Core of Moulds.



Finished Sinks.

CONCRETE WINDOW FRAMES.

The high cost of wood and metal have left scope for ingenuity in the use of other materials for the construction of window frames and an invention of M. W. Fontaine, of the École Industrielle, Brussels, is interesting in this connection. The frames are supplied ready for use and can be obtained in a variety of forms to meet all ordinary requirements. Openings must, apparently, be made of wood or metal, as at present, so that the saving effected is largely confined to the fixed portion of the windows. On the other hand, the use of concrete has the advantage of being unaffected by fire, weather, vegetation, and the other agents which destroy wood and iron, and concrete does not need any painting or other preservative. Concrete also enables very large window openings to be used with ease as the frames can be made of any dimensions in this material.

The prices of these "Cimarme" frames are much cheaper than those wooden or iron frames of the same patterns. They can be used in conjunction with wood or iron when required. The glass is fitted without the use of putty, a little lime mortar being used instead.

CEMENT NOTES.

By Our Special Contributor.

EXPANSION AND CONTRACTION OF CONCRETE.

There is much confusion in the use of the terms "expansion" and "contraction" when applied to concrete. If pipe-joints crack, or if cracks appear in a concrete floor or a cement-plastered wall, it is not uncommon to hear the blame ascribed to expansion, although in more than 90 per cent. of such cases the cause of the cracking is contraction. Similarly, the joints that are made when laying concrete roads are sometimes referred to as expansion joints, although their only function, in a country where extreme temperatures do not occur, is to prevent contraction cracks occurring.

This tendency to associate expansion with concrete is doubtless a legacy from last century when no standard specification existed and when expansion undoubtedly did occur in some instances. It may now be taken as a well-established fact, however, that no cement that complies with the British Standard Specification will expand, and expansion is only likely to occur in practice when aggregates containing coal or certain other injurious ingredients are used.

On the other hand, it may almost be said that a tendency to contraction is an inherent property of concrete, due to the fact that for the mixing of concrete it is necessary to use more water than can be absorbed by the cement for setting purposes and hence the excess water is eliminated by evaporation, thus causing a tendency to contraction.

A freshly mixed paste of neat cement contains about 20 per cent. of water, being the result of gauging the cement with 25 per cent. of its weight of water, but when this paste has set hard and been exposed for some time, the content of water has become reduced to 12 per cent. or 14 per cent., the former figure being all that is required chemically for the setting of the cement. This loss of water leads to a tendency to contraction, and if the loss occurs soon after mixing and while the cement is weak, it is unable to resist the formation of cracks. This is what happens when a neat cement pipe-joint is exposed to sun or wind as soon as it is made, or when cement plaster is applied to a porous material such as brick or tile which has not been thoroughly soaked with water. In the former case, the excess water is rapidly removed by evaporation and the cement is too weak to resist the tendency to crack, while in the latter case, the excess water is removed by absorption. The obvious remedy in the case of pipe-jointing is to protect the joint from rapid drying until it is hard, when it has sufficient strength to resist the tendency to crack.

When considering the case of cement mortar, a stiff mixture of 3 to 1 mortar would contain about 10 per cent. of water, which upon setting and exposure would be reduced to about 5 per cent., and hence a reduced tendency to contraction compared with neat cement. This explains why it is preferable to use sand and cement (1 to 1) for pipe jointing in preference to neat cement.

Enough has been said to show that contraction of concrete is not a defect to be associated with the cement but an inherent property, the effects of which can be reduced to a minimum by avoiding excess of water. The British Standard Specification ensures the absence of any expansive tendency in cement by the stipulations of the Le Chatelier test for soundness, but no test for contraction is embodied in the British Standard or any other modern national specification for cement.

To return to the distinction between expansion and contraction, it is obvious that if a concrete floor expands, the first sign will not be cracking, but either a pushing-out of the walls that surround it, or a bulging of the floor. It should be equally evident that when cracks appear in a floor, they are due to contraction, and occur because the reduced area of the concrete so caused cannot cover the space allotted to it. An exception to this may be referred to in an instance where a granolithic floor surface was laid upon a concrete base in which ashes containing coal had been used. The base expanded—owing to the coal—and naturally stretched the granolithic surface, thus forming cracks which were attributed to contraction until a closer investigation was made.

Again, in pipe jointing, if the cement joint expands, it could not fail to burst the socket of the pipe in which it is contained, and the opposite effect of cracking, which is always the cause of complaint when complaint does arise, is obviously due to the bulk of material having shrunk, not being sufficient to fill the space required.

Reference may be made here to the natural expansion and contraction of concrete due to temperature changes. This, as is well known, is almost identical with that of steel, and of such small dimensions as to be negligible within the limits of atmospheric temperature that occur in this country. The linear coefficient of expansion of concrete is ·000006 per 1° F., so that taking an extreme change of temperature of 80° F., a 10-ft. concrete bay would be about one-sixteenth of an inch longer on a hot summer day than on a cold winter day.

The application of concrete to absorbent materials such as brick or tiles requires particular care to ensure that these are thoroughly soaked with water before the concrete is applied. With tiles of some descriptions, merely dipping in water for a few seconds is quite inadequate, and it has been found that while this treatment will result in an absorption of about 7 per cent. of water, a further immersion for say six hours increases the absorption to as much as 16 per cent. Similarly the absorptive power of bricks may reach as much as 20 per cent. of the weight of the bricks, and thus when a brickwork surface requires to be plastered with cement mortar, it is obviously not sufficient to splash the surface with water from a brush, and if no more than this is done, contraction cracks become almost inevitable owing to the rapid absorption of the excess water in the plaster by the brickwork.

A curious phenomenon is occasionally observed when porous tiles are laid on a concrete bed in a confined position such as a corridor, the effect being that the tiles bulge upwards in such a way as to suggest that they are expanding. The expansion of tiles being regarded as an impossibility, the usual procedure is to accuse the cement joints between the tiles of having expanded, although the actual cause is the contraction of the underlying concrete bed.

CONCRETE MIXING.

It is held by some that the best of concrete mixers on the market will not produce so good a mixture as can be obtained by careful and intelligent hand mixing. If this view be accepted, however, the fact remains that the hand mixing of concrete is too costly for work of any magnitude.

It is important that the beneficial effect of thorough mixing upon the quality of concrete should be fully realised, and any efforts towards the perfection of the machine mixer encouraged.

Experienced cement testers know that an additional 50 lb or 100 lb. in the tensile strength of briquettes can often be obtained by prolonging the period of mixing. In a series of tests made by the writer, where sufficient cement was gauged for the moulding of three briquettes from each sample, it was observed that there was a marked tendency for the third briquette of each mixing to give the highest result of the batch.

The value of prolonged mixing is also brought out in some tests recently published by the American Society for Testing Materials on the "Rodding of Concrete." In the experiments described, concrete was filled into cylindrical moulds and a steel rod thrust into the concrete from 25 to 150 times at intervals. When the cylinders were tested under compression it was found that the rodded concrete gave results varying from 12 per cent. to 100 per cent. better than the unrodded concrete. The rodding of concrete in this way tends not only to better mixing but no doubt also releases some of the air imprisoned in the concrete and so yields a denser mass.

There is thus strong evidence in support of the belief that concrete may be materially improved by prolonging the time of mixing, always taking care that the concrete is finally in position before setting commences, and this points to the desirability of using a slow setting cement (not necessarily slow hardening) for all ordinary work.

HYDRATED LIME.

Among the improving materials that have been pressed upon the users of concrete during recent years is hydrated lime, and it is more worthy of comment than the rest because its name indicates precisely what it is. By its advocates, it is claimed that hydrated lime added to concrete renders it waterproof, makes it more workable and plastic, and increases its strength, while there are others who assert that hydrated lime is of no value in concrete, and money would be better spent in increasing the proportion of cement than in adding hydrated lime.

Tests are produced to support both contentions, and there is in fact a direct conflict of evidence which is somewhat bewildering to the plain man. It is possible the explanation of the difference of opinion is to be found in the method and period of mixing referred to in the previous paragraph.

There seems to be no doubt that hydrated lime does produce a " fatter " or more plastic concrete, and among certain large building contractors in America there is a firm belief that the cost of addition of hydrated lime to cement mortar is amply justified by the greater speed of working obtained by using a more plastic material.

A concrete containing a small proportion of hydrated lime if mixed for the same period as an ordinary concrete would probably give a higher test because it would be more plastic, leading to a denser and more homogeneous concrete, but if the ordinary concrete were mixed for a longer period than the concrete containing hydrated lime its strength would probably be equal, because the same degree of plasticity could be obtained.

An exhaustive series of tests by Prof. Duff A. Abrams, tends to show that hydrated lime is of no value in concrete, but in these tests the mixing was done by hand with a bricklayer's trowel in an iron pan, only sufficient concrete being mixed for one test piece, while the concrete was also rodded or puddled by a steel bar during moulding, and this probably resulted in very perfect mixing which would yield the best results from the plain concrete, and thus show no advantage from the use of hydrated lime. On the other hand, there is reason to believe that the tests made by the advocates of hydrated lime were on machine-mixed concrete where any deficiency in mixing might, to some extent, be counteracted by the presence of lime.

From a chemical standpoint, it is not to be expected that hydrated lime can have any value because the same compound is always produced when cement reacts with water, and is generally regarded as being inert so far as strength of cement is concerned. This view is supported by the fact that the addition of substances containing active silica (e.g., sodium silicate) adds to the strength of concrete by combining with the lime set free during setting. There is thus no benefit to be obtained chemically by addition of hydrated lime, and any advantage must be due to physical effects.

NEW APPLICATION OF CONCRETE;

FOR INTERNAL DECORATIVE PARTITION WALLING.

(*Contributed.*)

Councillor A. Davis, the inventor of the " Davis Patent System " of Flat construction, has designed a new method of utilising concrete for partition walling, to be worked either *in situ* or on the bench. He is now experimenting with it in the block of " Service Flats " his company are erecting at St. John's Wood, and so far, the experiment appears to be quite successful. As usual, the invention was the outcome of practical necessity and applied thought. A partition wall was to be built, and desirably of a decorative character, that is, panelled on both sides. A wooden frame was in position, awaiting the filling in. To solve the problem, Councillor Davis made plain deal frames, about 3½ in. deep, of the size of the spaces to be filled with panels, and fitted them in position, swung on central pins. The frame, being placed horizontally, and supported on either side, a sheet of expanded metal was nailed midway down, inside the frame. A workman then filled that side of the frame with concrete. When this was set, the frame was swung over, and the other side similarly treated.

This process was repeated for all the panels of the partition, their shapes

(*Continued at foot of p.* 826.)

CORRESPONDENCE.

Under this heading we invite correspondence.

The Problem of Collaboration.

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

SIR,—As an engineer with an appreciation of architectural beauty, but with many of the limitations which an engineer's training involves, will you allow me to emphasise Mr. Godfrey Page's contention, that collaboration between architect and engineer is essential from the earliest stages of a design, if beauty, utility and economy are to be achieved. His example, published in your October issue, strikingly illustrates this.

May I ask, however, how this is to be paid for? Is the building owner to be told he must employ engineer and architect and pay both? (Probably the most economical arrangement for him.) Is the engineer to be instructed by the building owner, and the architect to be employed by the engineer and paid by him? Is this position to be reversed and the engineer employed by the architect? Or, worst condition of all, nevertheless that which unfortunately prevails, is the engineer designer in reinforced concrete to be employed by the building contractor? Some of us have seen lamentable cases of failure through this latter course being adopted. In any case, the *building owner pays*, either directly or indirectly, for the services of both architect and engineer. Yet, how many architects or engineers are bold enough or able to convince the client that his best interest is met by employing both *directly himself*.

It is my good fortune to be collaborating with a number of architects in the manner suggested by Mr. Page, and our clients are saved many *hundreds of pounds* without knowing it; whereas, by following the pernicious (may I call it) practice of letting a building contractor submit "Estimates and Designs," the building owner pays, he thinks, for the cheapest design. Often he does nothing of the sort. His real saving *should* have come about when the architect and engineer thrashed out, ofttimes in the very early stages, the questions of practicability, efficiency and cheapness.

Mr. Page's ideal is recognised. How can it be made real?

Yours faithfully,
HARRY JACKSON.

(*Continued from p.* 825.)

and sizes being made to fit the scheme of the decorative wall. When all the panels were set, they were fixed, simply by driving home thin wooden wedges between them and the framework. Then, planed battens were nailed along and covering the joints, and the wall was complete, but for a coat of distemper or paint. The frames for the individual panels can also be filled in with concrete, in the shop, on a bench; when dry, fixed in position, and the rest of the treatment carried out as above. The result is said to be eminently pleasing, while that it is economical goes without saying, especially in a large building, such as a block of flats, where thousands of foot run of internal walling, of a more or less ornamental character, are required. For, all the working is simple, both the carpentering and the filling and fitting. The planed beading covering the joints, and marking the panelling, is the only skilled work required, and the cost of this can be set against that of the brick and plastering or concrete slab and plastering, or cement boards and papering, otherwise required.

The premises where this experiment is being carried out are not yet completed, and its final success awaits the test of proof in practice, but it is expected that partition walls so erected will be practically fire and sound proof, two things very desirable in large blocks of dwellings. Our thanks are due to Mr. Davis for enabling us thus early to publish the details of his new, ingenious and practical adaptation of that economical substance, concrete, as applied to internal walling. In his case, this concrete filling proved the more economical, as large quantities of broken brick were lying around, resulting from the demolition of the old mansion, on the site of which the new block is being built. Thus the main material cost Mr. Davis nothing beyond the cost of crushing; while in addition, he saved the cost of carting away otherwise waste matter.

NEW BOOKS
AT HOME AND ABROAD

A short summary of some of the leading books which have appeared during the last few months.

Columns. By E. H. Salmon, D. Sc.
Henry Frowde & Hodder & Stoughton. 31*s.* 6*d.* net.

This book, which is a work of some 270 pages, is stated in the preface to be approximately one-third of a treatise which the author submitted in 1916 as a thesis for his degree of D.Sc. The work shows evidence of a very careful searching and study of what has previously been done by others and a bibliography of about 300 references is given in the beginning, and the author draws freely from all these sources for his compilation.

While experimental results are occasionally referred to, the book consists mainly of theoretical treatises and formulæ. In fact, though a very large number of formulæ are not numbered, those which are aggregate over 500.

The author gives mathematical treatment for position fixed, direction fixed, and flat ended columns, and columns with both ends fixed in position and one end in direction.

He discusses lattice braced columns and bending in several planes, and then discusses at great length imperfections in columns under which he includes imperfections in material, manufacture, and conditions of loading and their effect on eccentricity of loading, initial curvature and reduction in strength of the material.

The work may perhaps be described as an excellent resumé of the theoretical work and suggestions which has been done on the subject up to date, and the author does not express any definite views of his own so much as state in a collective form the views of others, and it is obvious that a compilation of this kind is often of very great value.

The author apparently comes to the conclusion—page 253—that the safe working stress in compression should be 20 per cent. less than that proper in tension to allow for reductions in the quality of the material. We find this a little difficult to agree with, since presumably a tension member is subject to all the accidents of workmanship, manufacture, material and accidental eccentricity which may apply to a compression member, except, of course, in the case of flexible tension members which, however, are not specially referred to, or implied. Columns of reinforced concrete are not specially considered, and most of the theories would not be applicable to them.

We think it may be seriously questioned whether, except perhaps in the case of very slender columns, further mathematical work will advance our knowledge appreciably. There are, in fact, so many theoretical treatments giving results which differ considerably in the same column, and apparently the only means of finding out which approximates most to the truth is to compare them with actual experiments. In these conditions it would appear that we may as well go direct to results of experimental work for our information of what is safe in practice and take our results from curves plotted from experiments without worrying whether these curves can or cannot be put into complicated mathematical form, but the present treatise does not take us much further in this direction.

At the end of the book a few examples are given, the first being the determination of the safe concentric load on a 6 + 5 mild steel joist 100 in. long, ends fixed in position, and the result is worked out in various ways, and figures are obtained of 37·2 tons, 31·3 tons, 46 tons, 32·8 tons, 33·7 tons. A second example gives by different methods results of 37·2, 31·3, 42, 46, 46·2, 45·7. The author leaves us in doubt as to which of these results he considers should be adopted unless we may conclude that one of these methods which he calls the rational method is the one whose results we should accept. What would, of course, be interesting would be to have some experimental results of the actual example and compare this with the various figures given by the different theoretical formulæ.

The reviewer's feeling that further experimental work and not further theoretical work is the requirement to-day is increased by his feeling that the end conditions, such as ends fixed in direction, and so on, are in practice never attained and it is impossible, in practice, to say which end conditions ought to be assumed in the theoretical investigations on the formulæ resulting therefrom. We consider the work, as a compilation of the theoretical work on the subject done up to date, may be thoroughly recommended in every way.

O. F.

Old London Illustrated. A Series of Drawings by W. H. Brewer, with descriptive notes by H. A. Cox, F.C.A.

Published by "The Builder," Ltd., 4 Catherine Street, London. Price 3s. 6d. net.

It would seem as if there is at last to be a recrudescence of the interest of the Londoner in his city. There are many contemporary activities, some of which may be causes and some results, but all acting and reacting upon each other and upon the public mind to produce this desirable awakening. Among these can certainly be set the opportune publication of Brewer's drawings, wisely rescued from oblivion by the proprietors of "The Builder," in which journal they were first published between the years 1884 and 1898.

The London with which these illustrations deal is the London of the sixteenth century; a period that is, and rightly so, considered pre-eminently picturesque, but it must be remembered that picturesqueness is not an architectural quality, it is a mysterious pervasion which buildings acquire under the mellowing process of time, and from which, strange as it may seem, even the worst buildings are not immune. We are so bold as to predict that a successor of Mr. Brewer, who may "re-construct" with equal skill that strange and heterogeneous agglomeration of buildings known as the Strand for the edification of the Londoners of the twenty-fifth century, will arouse in his contemporaries similar sensations, similar yearnings, and the quality which they will be most quick to appreciate will be just that picturesqueness which we to-day find so enchanting in the reconstructed London of Henry VIII.

Brewer, however, was not a draughtsman who emphasised the picturesqueness. His work is the result of scholarship and research rather than of imagination or inspiration. He appears to be interested in, rather than moved by, his subjects, and his drawings are the result of a clear, sharp intellect rather than an impetuous passion; they do not reveal him as a man caught by the spirit of the age which he portrays, but as an unbiassed historian. He is topographical rather than pictorial, and he is objective rather than subjective. But these are all qualities which enhance the value of his works for architects, and who are themselves able to translate a building into terms of life, and prefer to have their material presented in its purest form.

One outstanding quality that distinguishes the architecture of the London depicted in Brewer's drawings from that of to-day is the absence of self-consciousness; it is patent that the builders of that age were not beset by questions of style, nor were they troubled by academic discussions as to whether they should design in this or that *period*, such indecisions are the penalty that we pay for our increased scientific and historical knowledge. There is here scope for an alluring digression showing that as we tend to eliminate time and space with our scientific inventions and intellectual achievements, the law of compensation is avenged, for our more ample vision begets introspections and hesitations.

Those who may be led away by the glamour with which the past invariably envelopes itself will do well to read with care the concise descriptive notes of Mr. Cox, that amplify and explain each plate. Therein they may be reminded that the intervening four centuries have brought relief from some of the grosser discomforts with which the daily activities of those erstwhile denizens of London were beset. "Except for a central gulley in such a wide thoroughfare as this (Cheapside) the streets were not drained even for surface water," we read, "and the houses had no drainage system. Waterspouts discharged their contents upon the passers-by in the streets, and receptacles were emptied from the windows. We may presume that most of the water found its way to the river sooner or later!" There will, however, remain justifiable grounds for many regrets, chief amongst which is the absence of that vulgarity that to-day renders certain parts of our great cities a never-ending abhorrence. It has, with reason, been postulated that we turn our inventions as readily to evil as to beneficial uses, and corroboration is instantly forthcoming by the manner in which we desecrate the beauty of the day, with the aid of printing, by mutilating the sides of our buildings with monstrous placards, and violate the mystery of the night, with our newly found knowledge of electricity, by scintillating monstrosities of commercial arrogance. Such outrages our forefathers were spared, and their London, as we see from these drawings, was characterised in its buildings by reticence, modesty and good workmanship. May the perusal of this volume help to inculcate once more these virtues.

To the engineer the greatest interest will, perhaps, centre in the account and in the drawing of London Bridge, which, it so happens, is one of the best in the book. "The foundations of the bridge were of wood. Great platforms, called sterlings or starlings, were formed by driving piles into the mud and erecting upon them the platforms upon which the stone piers were built." Mr. Cox has not hesitated to diversify his informative notes with a charming anecdote, and one such adorns that which deals with London Bridge.

It is sincerely to be hoped that this book, moderate in price, eloquent in praise of London, and redolent of historic interest, may achieve the full popularity that it deserves. Latent interest will be aroused and existing interest will be stimulated, and from the contemplation and appreciation of London of the past, London of the future will assuredly benefit.
H. J. B.

The Report of the Third Congress on Housing * which has just been published, deals in a most interesting manner with the use of electricity as a heating agent for domestic purposes. Curiously enough, the French appear to be much behind Italy, Switzerland, and even Great Britain in this respect.

Unfortunately, the Congress did not spend any time on building materials.

* *Troisième Congress de l'Habitation*, 1921. Lyons : Noirclerc et Fenetrier.

(Continued from p. 794.)

(11) Don't leave mixed concrete standing during meal hours nor allow concreting to be discontinued until each part is completed. In case of accident or enforced stoppage remove concrete which cannot be completed for a part.

(12) Don't use concrete when more than 15 to 20 minutes old, but reject it. Watch intervals for meals.

(13) Don't allow the dumping of concrete out of the mixer until the mixer has made at least twelve turns since the last material was added although the mix may appear acceptable.

(14) Don't allow the coarse material to separate from the mortar but keep on mixing the concrete during transport and placing.

(15) Don't dump concrete into water or from a height more than 6 feet.

(16) Don't forget to see that forms are washed out clean immediately before concreting and that they are tight and braced.

(17) Don't leave concrete without being punned immediately after placing.

(18) Don't allow construction joints except where shown or described as permissible.

(19) Don't forget to chip off spilt concrete and loose and rough parts and hack construction joints for bond and clear the forms.

(20) Don't let concrete dry out too quickly but keep it wet for at least a week in hot weather.

(21) Don't strike important forms until concrete is fairly hard and rings when hammered on.

(22) Don't forget to verify that the reinforcement is provided as shown on drawings accurately for each part, watch number and diameter of bars.

(23) Don't allow butt joints of main bars but insist on proper lap, say 30 in. over hooks for ordinary sizes and in any case not less than 40 times the diameter, and allow splice only in places where approved.

(24) Don't allow main bars to stop short at ends and see that shear steel is properly placed.

(25) Don't allow too close placing of bars in concrete, particularly at junctions of beams and at columns. Watch vertical bars in columns at beam levels.

(26) Don't allow sharp bends of main bars in columns and beams except at ends for anchors.

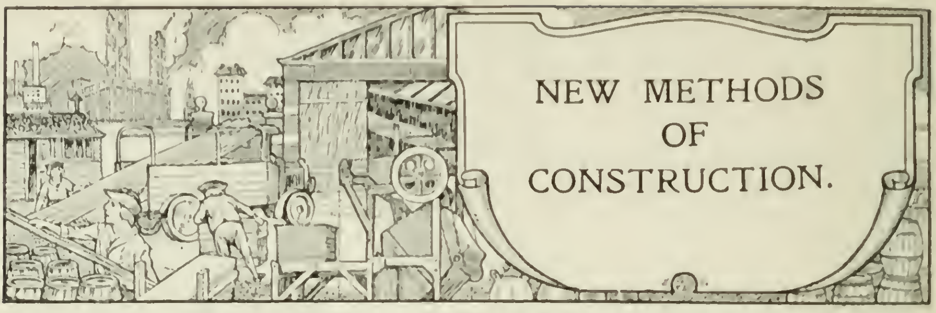
(27) Don't omit anchor ends and hooks on sheer members, links and hoops to extend sufficiently into the concrete. Hooks round steel bars are not sufficient. Bars in compression must be held by links to prevent buckling.

(28) Don't forget to take concrete cube samples of concrete as poured and note particulars for record and testing.

(29) Don't rely on the safety of a structure unless materials are tested and concrete is tested and work inspected in detail.

(30) Don't do important reinforced concrete work without one competent person being appointed with authority to issue instructions and supervise, approve or reject the work and accept responsibility.

(31) Don't estimate cost of reinforced concrete without complete description and details to illustrate the kind of work required. It is a bad policy to give out a contract at a losing price, as scamped work possibly will result.



THE "EXPRESS" CONCRETE BUILDING FORM.

The particulars of New Methods published under this heading are based upon details and information supplied by the different firms putting forward these systems of construction.—Ed.

The "Express" Concrete Building Form provides a simple and inexpensive means of erecting monolithic hollow concrete walls on the "travelling mould" principle. The mould itself, as will be seen in the illustrations, is formed of four partitions

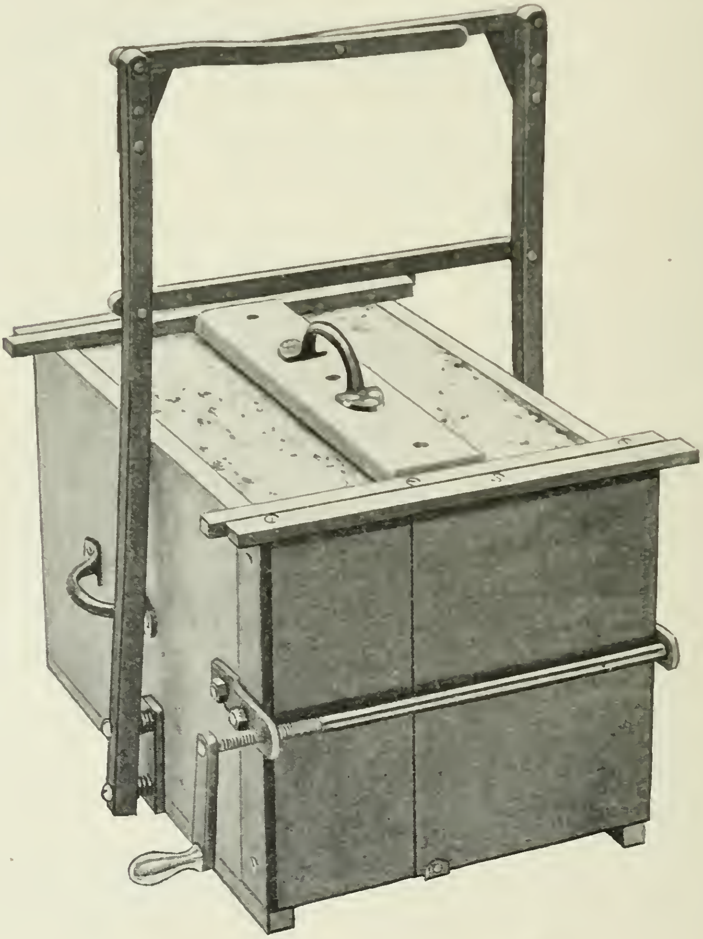


Fig. 1.

closed at one end by sliding metal plates operated by a screw worked by a crank and handle. Each outer partition is joined by a metal rod or band to the next partition but one, so that when the partitions are drawn outwards in order to release the mould, the two inner ones forming the cavity are drawn together until their surfaces come into contact. *Fig.* 1 shows the filled mould before release, and in *Fig.* 2 the partitions are seen to be drawn away from the concrete, the mould being ready to be moved. along for concreting the next section.

In commencing to build a wall the concrete foundation is laid in the ordinary way, two or three inches projecting above the ground the exact thickness of the wall required. The form is then placed upon this, and the sides adjusted by means of the screw until the overlapping lower edges of the outer partitions grip the two or three inches projecting. For the first fill the second end of the form is closed by a wooden board fastened on temporarily. After the first fill this is unnecessary as its place is taken by the ends of the two slabs just laid.

The corners are made in small corner moulds specially devised. No difficulty is experienced in the spacing of doors and windows as the mould can be placed so as to overlap on the portion of the wall already constructed.

The spaces for joists to rest upon are provided by inserting blocks of wood in the inner section of the mould. These are withdrawn after the concrete has set, thus allowing the joists to rest on the solid wall.

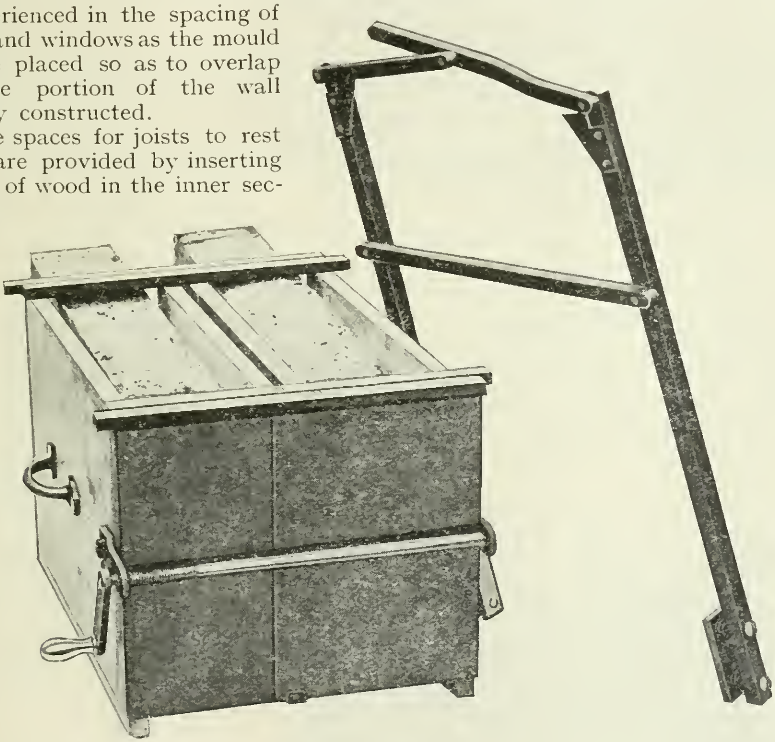


FIG. 2.

As is the case in all moulds operating on this principle, a dry mixture, well tamped, is employed. Generally speaking, a course laid one day will have set sufficiently to have another superimposed the day following, although it is stated that under very favourable conditions two courses have been laid the same day.

This mould is very simple, light and easily handled, and there is no mechanism to get out of order. A workman of average intelligence should be able to use it efficiently with two or three days' practice, and it should therefore commend itself to those in the building trade who are seeking to assist the unemployed.

Particulars of this patented system may be obtained from The Express Concrete Building Co., 52 Bishopsgate, where the machines may be seen.

MEMORANDA.

Memoranda and News Items are presented under this heading with occasional editorial comment. Authentic news will be welcome.—ED.

French Tidal Power Scheme.—The construction of a tidal power-station on the estuary of the Diouris, a small stream which enters the sea at Aber Vrac'h, in Finistère, about 15 miles north of Brest, is proposed by the Société Financière pour l'Industrie.

The plans involve the construction of three reinforced concrete caissons in the middle of the estuary, together 70 metres wide. The largest, in the centre, will contain the turbines; its bottom will be 13·20 metres below standard water-level, and its top 12·80 metres above, or 4·30 metres higher than the level of spring tides. Flanking this caisson on each side will be two smaller ones, to contain sluices. The caissons will be connected to each shore by masonry walls, giving the barrage a total width of about 150 metres. A lock will permit the passage of ships.

The turbines installed in the central caisson will be of the Escher Wyss type, designed to generate while running in either direction, to block the passage completely or act as sluices, and to operate as pumps. On a rising tide the water will flow from the sea into the inner basin through the turbines, and when the level of the water is the same on both sides of the barrage, the turbines will be stopped, until with the ebbing tide the level of the sea falls sufficiently to enable them to be operated again with the water from the basin. In addition there will be a second reservoir, constructed on the Diouris just above the limit of the tidal range, to feed a second generating station. It is estimated that the tidal turbines will supply about 7,900,000 kw. hours, of which the industrial load will absorb 5,500,000 kw. hours. The surplus will be employed in pumping water into the upper reservoir, the station in connection with which will furnish 3,900,000 kw. hours.

Bridge in Course of Construction.
HIGHWAY BRIDGE IN SIERRA LEONE.

Concrete Highway Bridge in Sierra Leone, West Africa.—The bridge, see illustrations, which carries the main road between the villages of Allen Town and Hastings in the Gold Coast Colony proper over the (tidal) River Orogoo, was designed by the Public Works Department and carried out by that department with West African labour.

Work was commenced during the rainy season of

1920, and the bridge finally opened early this year.

There are three spans of 25 ft., carrying a roadway of 16 ft. 6 in. clear width. The cross-section is of four T-beams each 2 ft. in depth, with 9 in. side walls designed as rectangular beams and a 7 in. concrete deck reinforced with expanded metal.

The bridge crosses the stream obliquely and the stream piers form a natural cut-water.

One of the illustrations shows the palm-leaf roof erected to protect the reinforcement and the concrete from the direct rays of the sun during pouring operations—a very necessary procedure in the tropics.

Completed Bridge.
HIGHWAY BRIDGE IN SIERRA LEONE.

Clean Concrete Paving Joints with Automobile Exhaust.—An inexpensive method for cleaning joints and cracks in concrete pavement before filling with tar has been devised by a firm of contractors in U.S.A.

The method involves the use of a 30-ft. length of $\frac{3}{4}$-in. rubber hose, provided with a $\frac{1}{2}$-in. gas pipe nozzle. The hose is attached to the exhaust pipe of the small motor truck used for hauling the tar kettle and other tools. The end of the gas pipe nozzle is drawn down to $\frac{1}{4}$ in. diameter. The crack or joint to be cleaned is first freed from any tightly packed dirt by means of a metal clean-out hook. The material thus loosened is then dislodged by directing the exhaust pressure of the motor, by means of the hose and nozzle, into the joint. The motor is speeded up to produce the necessary pressure at the nozzle. This method leaves a clean crevice. The exhaust gases, being warm, evaporate any moisture that may be present in the edges of the concrete, thus ensuring a good bond between the concrete and the hot bituminous filler. The method is stated to be much quicker and more effective than the commonly used street broom, especially in getting rid of the fine dust which, if left in the crevices, may prevent the bitumen from adhering to the concrete.—*The Concrete Highway Magazine.*

Proposed Portland Cement Works—Jamaica.—The *Board of Trade Journal* states that the Government of Jamaica is understood to be taking considerable interest in a project for the establishment of a Portland cement industry in Jamaica, which if proceeded with may, it is anticipated, absorb most of the Portland cement trade in the West Indies. Copies of a report on the possibility of establishing such an industry in Jamaica, and any further information desired, may be obtained from the Department of Overseas Trade, 35 Old Queen Sreet, S.W. 1.

TRADE NOTES AND CATALOGUES.

Reinforced Concrete Roads.—B.R.C. Fabric will be used in the construction of section No. 3 of the North Circular Road, to be carried out under the direction of F. Wilkinson, Esq., M.I.C.E. Surveyor, Willesden U.D.C., for the Middlesex County Council in conjunction with the Ministry of Transport.

MacGraw Hill Publishing Co. have just issued their Catalogue of Technical and Scientific Books ; this can be obtained by any one interested on application to the above firm at 6 and 8, Bouverie Street, E.C.4.

Reference Handbook for Reinforced Concrete.—This has just been issued by

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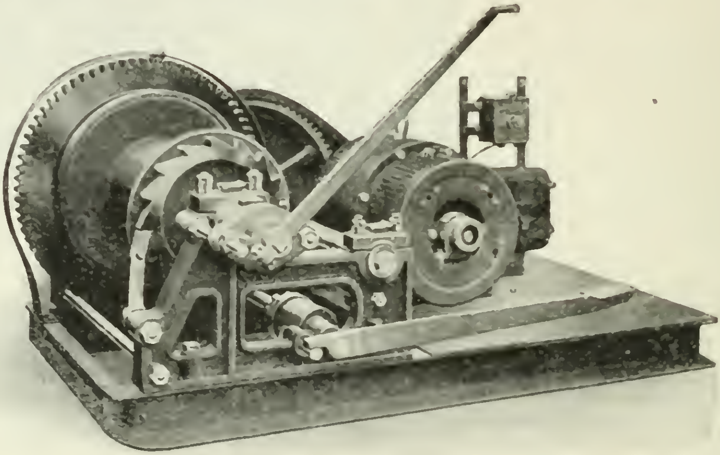

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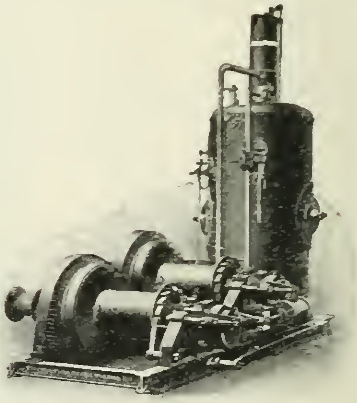


END VIEW OF DOUBLE BARRELLED STEAM WINCH.

DOCK HOUSE, BILLITER STREET, LONDON, E.C.3.

Messrs. Johnson's Reinforced Concrete Engineering Co. Ltd., of Manchester, and contains useful data and information regarding their special reinforcement, which, we understand, is now being used extensively for road work. We are informed that engineers and architects will be supplied with a copy on application to the above firm at Lever Street, Manchester.

Manchester Town Planning Roads.—Concrete Town Planning Roads are being laid by the Manchester Corporation under the direction of Mr. J. B. L. Meek, City Engineer, and the sections of roads that are being reinforced are by the Walker-Weston Double-Layer Framework. On Road No. 12 there are two sections; on Road No. 25 (Slade Lane to Moseley Road) there are two sections; on Road No. 25 (Moseley Road to Mauldeth Road) there is one section. At all these places the road is constructed on filling, and the Walker-Weston Reinforcement used is that known as "Pattern B" and weighs 16 lb. per square yard. The width of roads between kerbs is 20 ft. and the Reinforcement is carried underneath kerb 18 in. on either side of carriage-way.

A Large Gasholder.—Recently a large gasholder of 15,000,000 cubic feet capacity has been completed at Astoria, New York. The holder is constructed of reinforced concrete; 1,200,000 lb. of concrete and 1,000,000 lb. of steel were used for the bottom and retaining wall of the gasholder. The floor of the tank is reported as being not over 18 in. in depth, but the cylindrical wall which must withstand the weight of 48 ft. of water is 9 ft. thick at the bottom and 5 ft. thick at the top.

ERRATUM.

The article on "Floor and Column Forms for a typical whole reinforced concrete building," by Mr. H. C. Johnson, which was referred to in our August number in connection with the article on the Fordson works, appeared in *May*, 1912, of this journal and not in January, 1913, as stated.

TENDERS INVITED.

Dock Works in Belgium.—Tenders are invited for the construction of a dry dock at Largerbrugge, near Ghent, regarding which further particulars may be obtained at the Department of Overseas Trade, 35 Old Queen-street, Westminster, S.W. Tenders for this work have to be in by January 13. Information may also be had from the Department of Overseas Trade regarding a contract for the enlargement of the Brussels-Charleroi Canal, the construction of a maritime dock at Kruisschaus, and the construction of a quay wall (about 1,600 metres) at Austruweel. Tenders for these three works have to be submitted by January 2.

Concrete Grain Elevator for Bulgaria.—Tenders are invited for the construction of a concrete grain elevator of 30,000-tons capacity, and a drying shed at the port of Varne. The sending-date for tenders is February 15. Further information may be obtained from the Department of Overseas Trade, 35 Old Queen-street, Westminster, S.W.

TENDERS ACCEPTED.

Barnsley.—The Barnsley Town Council has been recommended to accept the tender of Messrs, C. D. Potter for the erection of a reinforced concrete roof at the police office, for the sum of £120.

Bentley.—The tender of the Yorkshire Hennebique Contracting Co., of Leeds, has been accepted by the Bentley Urban District Council for rebuilding the Cooke Street Bridge, for the sum of £1,935.

Elgin.—The Elgin County Council has accepted the tender of the Yorkshire Hennebique Contracting Co. for the construction of a reinforced concrete bridge over the river Spey, for the sum of £4,850.

Grimsby.—The Grimsby Town Council has accepted the tender of Messrs. Wright & Co., of Lincoln, for the erection of ferro-concrete silos, for the sum of £1,757 1*s.* 10*d.*

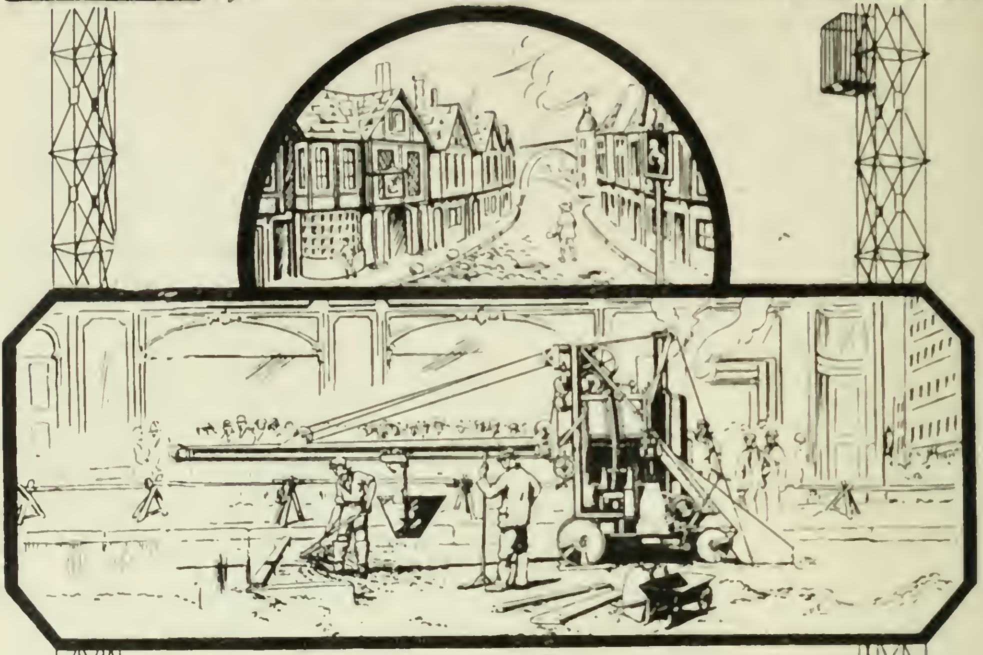
Lancashire.—The Lancashire County Council has awarded a contract, at £9,000, to Messrs. Parkinson & Sons for the erection of five pairs of type "B4" (urban) cottages at the Halewood Estate. The cottages will be constructed of reinforced concrete.

London.—The Metropolitan Water Board has accepted the tender of Messrs. Hughes & Muirhead, for covering the Kiddenpore reservoir with a coating of 1-inch specially prepared concrete, for the sum of £767.

London.—The Battersea Borough Council has accepted the tender of the British Reinforced Concrete Engineering Co., Ltd., at £347 9*s.* 11*d.*, for the supply of Fabric reinforcement for the concrete foundation for houses on the Latchmere Estate extension.

Salford.—The Salford Town Council has accepted the tender of Messrs. Naylor Bros., of Sheffield, for the supply of concrete blocks, for the sum of £237 10*s.*

Suffolk.—The West Suffolk County Council has accepted the tender of Messrs. Parker & French, of London, for the construction of two sections of reinforced concrete road between Bury St. Edmunds



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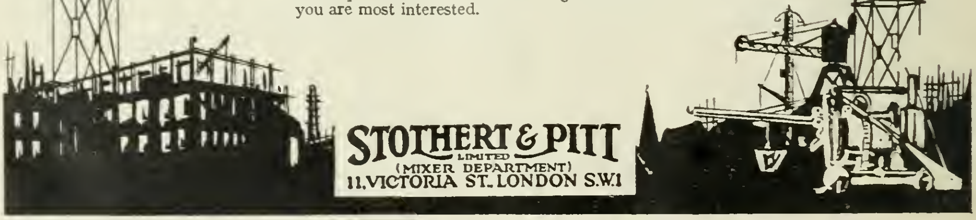
Particulars of the Victoria Mixer are contained in our catalogue M.D. 103, while full particulars of the Smith Mixer will be found in catalogue M.D. 102. Either of these are free on request. Please write stating in which you are most interested.



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and Great Barton, for the sum of £3,214 12*s.* 6*d.* Other tenders received were : S. H. Greasley, Leicester, £3,259 7*s.* 11*d.* ; H. C. Pullar & Co., Manchester, £3,450 18*s.* 3*d.* ; Radford, Tebbs & Co., Derby, £3,537 14*s.* ; Ernest Howes, Ixworth, £3,674 17*s.* ; P. Wilson & Co., Exmouth, £3,845 ; L. J. Speight, London, £4,000 ; Thorby & Matthews, Westcliff-on-Sea, £4,122 13*s.* 3*d.* ; J. Dickinson & Co., Ltd., Bolton, £4,325 ; R. J. May, Norwich, £4,550 ; W. Church, Lowestoft, £4,600 ; Norman Buckley, Weymouth, £4,844 2*s.* 9*d.* ; Broadway Construction Co., London, £5,150 16*s.* ; H. J. Jackson, Biggleswade, £5,422 15*s.* 4*d.* ; Lambrick & Co., Burton-on-Trent, £5,506 12*s.* 6*d.* ; Thomas Howes, Norwich, £5,566.

PROSPECTIVE NEW CONCRETE WORK.

BIRMINGHAM.—*Reservoir.*—The Birmingham Corporation has authorised the Water Committee to incur expenditure up to £500,000 in connection with the construction of a storage reservoir at Frankley.

BLACKBURN.—*Road.*—The Blackburn Town Council has decided to proceed with the construction of an arterial road from Brownhill to Bank Hey.

BRISTOL.—*Dock Sheds.*—The Bristol City Council proposes to seek Parliamentary sanction to borrow the sum of £187,000 for the purpose of replacing the dock sheds with modern structures.

CLEATOR MOOR.—*Sewage Works.*—The Ministry of Health has held an inquiry into the application of the Cleator Moor Urban District Council for permission to a loan of £17,500 for sewage disposal works.

CRAMLINGTON.—*Sewage Works.*—The Ministry of Health has sanctioned the borrowing of £17,700 for sewage disposal works, by the Cramlington Urban District Council.

DARLASTON.—*Sewage Works.*—Application has been made to the Ministry of Health by the Darlaston Town Council for sanction to a loan of £42,000 for sewage disposal works.

DUNDEE.—*Waterworks.*—The Dundee Water Commissioners are considering the question of applying to the Scottish Board of Health for sanction to a loan of £100,000 for extension and improvements in connection with the water supply.

FRASERBURGH.—*Harbour Works.*—Sanction has been received by the Fraserburgh Town Council to loans of £31,250 and £2,000 for extensions and repairs to the breakwaters at the harbour.

GISBORNE (N.Z.)—*Bridge.*—A reinforced concrete bridge is to be constructed by the Gisborne (New Zealand) municipality. The bridge will be 370 ft. long by 40 ft. wide.

GLASGOW.—*Road.*—The Glasgow Corporation has decided to proceed with the construction of a new road between Scotstown Hill and Dumbarton Road.

GREENOCK.—*Harbour Works.*—The Greenock Harbour Trust is considering a scheme for the erection of a landing stage, storage sheds, and oil tanks near Princes Pier, Greenock.

HALSTEAD.—*Sewage Works.*—The Halstead Urban District Council has applied to the Government for financial assistance in carrying out a sewage disposal scheme, at a cost of £18,000.

HARWICH.—*Sea Wall.*—The Harwich Town Council has decided to proceed with a scheme for the erection of a sea wall at Dovercourt, at a cost of £10,000.

HORNSEA.—*Sea Wall.*—A sea wall, to cost about £120,000, is to be constructed by the Hornsea Urban District Council.

KINGHORN.—*Waterworks.*—A proposal for providing a new waterworks, at a cost of £25,000, is being considered by the Kinghorn Town Council.

KEIGHLEY.—*Reservoir.*—The Waterworks Committee has recommended the Keighley Town Council to proceed with the construction of a covered reservoir at Bracken Bank, at a cost of about £27,000.

LLANELLY.—*Water Supply.*—The Llanelly Town Council is considering the question of carrying out a new water supply scheme, at an estimated cost of £200,000.

MITCHAM.—*Sewage Works.*—The Ministry of Health has held an inquiry into the application of the Wandle Valley Joint Sewage Board for permission to borrow £300,000 for the purpose of additional sewage disposal works.

RAMSGATE.—*Road.*—A new arterial road is to be constructed by the Ramsgate Town Council, between Grange Road and the Canterbury Road.

REDCAR.—*Road.*—A scheme for the construction of an arterial road through Dormanstown is under consideration by the Redcar Urban District Council. The cost of the proposal is estimated at £80,000.

RUGBY.—*Sewage Works.*—The Rugby Urban District Council has applied to the Ministry of Health for sanction to a loan of £12,400 for sewage disposal works, and an inquiry has been held.

SEDGEFIELD.—*Road.*—The Sedgefield Urban District Council has decided to apply for a loan of £10,000 for the construction of a new road at Trimdon Grange, at a cost of £10,000.

SHEFFIELD.—*Public Works.*—The Sheffield Corporation has approved of schemes estimated to cost about £1,000,000 for public works, including sewage works, filter beds, and tramways.

SWANSEA.—*Roads.*—A number of road improvement schemes have been approved by the Swansea Town Council, at a cost of over £100,000, and submitted to the Ministry of Health for approval.

UXBRIDGE.—*Reservoir.*—The Uxbridge Urban District Council has instructed its Surveyor to prepare plans for a new open reservoir, with a capacity of 1,000,000 gallons, to be built on Uxbridge Common.

WARWICKSHIRE.—*Roads.*—The Warwickshire County Council has agreed to the construction of a new road at Castle Bromwich, at a cost of £16,000, and other road improvements in its area.

WOOLWICH.—*Roads.*—Application has been made to the London County Council by the Woolwich Borough Council for sanction to borrow £140,000 for the construction of new roads on the Well Hall housing estate.

NEW COMPANIES REGISTERED.

LANCASHIRE REINFORCED CONCRETE POST CO., LTD. (177,376), 116 Fylde Road, Preston, Lancashire. Registered October 20. Dealers in and Manufacturers of concrete posts. Nominal capital, £2,000 in 2,000 £1 shares. Directors: E. Smith, Skerton Road, Lancaster; J. Thornton, 4 Bray Street, Ashton-on-Ribble; and J. H. Thwaites, Preston. Qualification of Directors, 200 shares; remuneration to be voted by Company.

CENTRIFUGAL BEAM CONSTRUCTION CO., LTD. (177,395). Registered October 21. Manufacturers of concrete, hollow concrete beams, and other building materials. Nominal capital, £22,000 in 20,000 £1 cumulative preference shares and 40,000 ordinary shares of 1s. each. Directors: L. Alwyn, 100 Henley Road, Ilford; and E. H. Herbert, Swan Chambers, Great Swan Alley, London, E.C. Qualification of Directors £25; remuneration £50 each.

JOSEPH H. BRADSHAW, LTD. (177,496), 34 John Dalton Street, Manchester. Registered October 26. To acquire and carry on business as asphalters, concretors, road-makers, general contractors, and public works contractors. Nominal capital, £3,000 in 3,000 £1 shares. Directors: J. H. Bradshaw, Oaklands Drive, Ashton-on-Mersey, and A. A. Smith, Hyde Bank, Romiley, Cheshire. Qualification of Directors, £5 each; remuneration to be voted by Company.

RECENT PATENT APPLICATIONS.

142,483.—Truscon Steel Co.: Manufacture of composite tapered shingle.
146,243 and 169,781.—A. O. Crozier: Hollow articles of cement.
149,266.—J. Stone: Casting concrete below water-level.
150,312.—M. Fatio: Concrete building blocks and slabs.
169,212.—E. W. Roberts & L. F. W. Leese: Building blocks and building construction.
169,282.—E. W. Roberts & L. F. W. Leese: Building blocks.
169,283 and 169,284.—E. W. Roberts & L. F. W. Leese: Shuttering for concrete wall construction.
169,328.—M. M. Smith: Concrete building block machine.
169,516.—I. J. Pedersen: Building units.
169,583.—J. King: Shuttering for concrete slabs, blocks, and other similar units formed *in situ*.
169,729.—E. Airey: Moulds for the construction of concrete blocks and slabs.
169,762.—R. Wilson: Concrete building construction.
169,778.—S. Sokal: Beams and girders.
169,782.—A. Buchele: Hollow walling construction and building blocks.
169,786.—P. Dumont: Lime kilns.
169,807 and 169,808.—H. Wade: Manufacture of cement mixtures and cement.
169,850.—J. W. Laing: Forms for concrete wall construction.
170,033.—W. P. & P. G. Hayes: Concrete construction.
170,063.—H. Wade: Manufacture of slow-setting cement.

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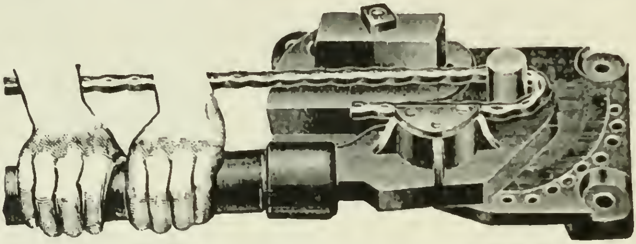

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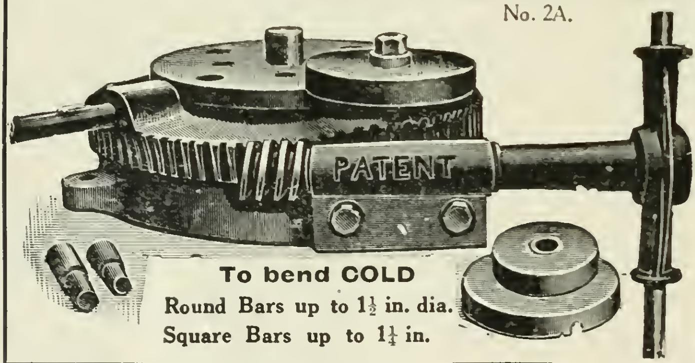

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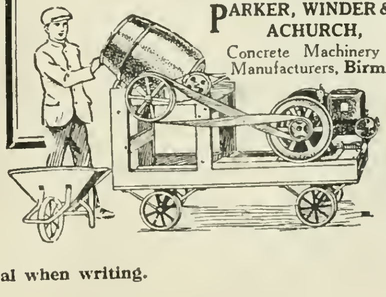

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